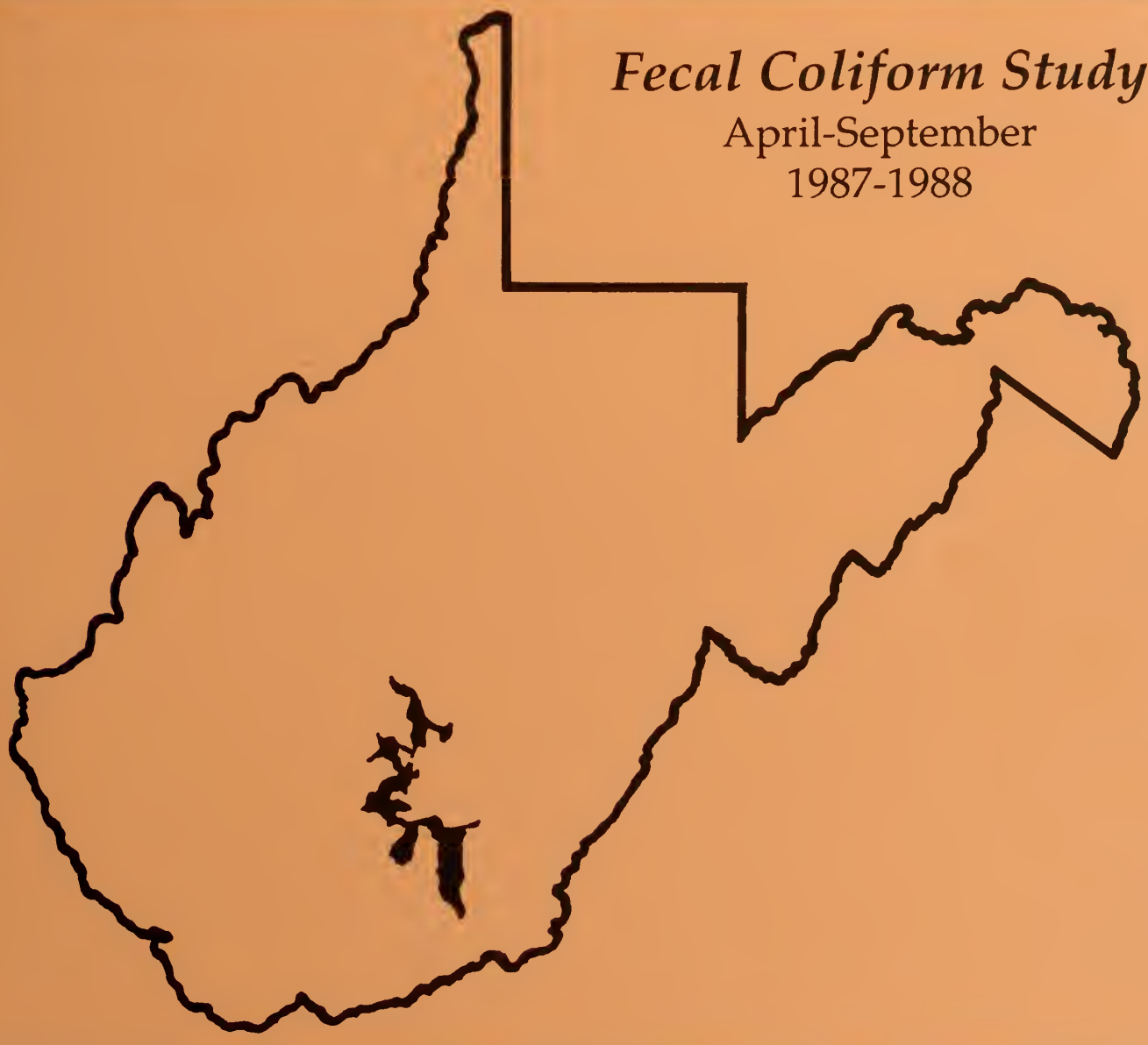
NEW RIVER GORGE
National River



Fecal Coliform Study

April-September
1987-1988

West Virginia Department of Natural Resources

Division of Water Resources

Monitoring Branch

NEW RIVER GORGE NATIONAL RIVER
FECAL COLIFORM BACTERIA SURVEYS REPORT
1987-1988

Prepared for the National Park Service
New River Gorge National River

by

West Virginia Department of Natural Resources
Division of Water Resources
Monitoring Branch

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ABSTRACT

Water samples for fecal coliform bacteria analysis were collected five times per month during the water contact recreation period from April through September at 14 sites (9 mainstem and 5 tributaries) in 1987 and 15 sites (9 mainstem and 6 tributaries) in 1988 in the vicinity of New River Gorge National River. The objectives of this work were to determine which of these sites had bacteria concentrations in violation of the West Virginia water quality criterion applicable to New River and its tributaries (monthly geometric means not to exceed 200 counts/100 ml nor more than 10% of monthly samples to exceed 400 counts/100 ml) and to ascertain if bacteria levels exhibited patterns associated with flow regimes and seasonal variations.

New River mainstem station N-2 (immediately below the Hinton sewage treatment plant discharge) was in violation of the criterion every month sampled in both years. In 1987 all other mainstem sites exceeded the criterion at least once during the spring period of April and May. However, in the spring of 1988 violation of the criterion occurred only once at each of two sites on New River other than N-2. Bacteria concentrations in the summer of 1988 were higher than in the summer of 1987 although violations of the geometric mean portion of the standard occurred at only 3 of the 9 mainstem sites. Both the lower spring concentrations and the higher summer concentrations in 1988 relative to 1987 were considered responses to drought conditions in 1988.

In 1987 all tributary sites exhibited seasonal patterns similar to the mainstem stations, i.e. violation of the criterion in spring followed by lower summer concentrations. However, in 1988 no clear patterns emerged. In both years bacteria concentrations varied widely among the tributaries. The Laurel Creek site had the lowest levels. Meadow Creek and Wolf Creek exhibited violations about half of the months sampled. Violations were detected on Dunloup Creek all but one month of the study period. Piney and Arbuckle Creeks, and Marr Branch were in violation of the criterion every month. Piney, Dunloup and Arbuckle Creeks, and Marr Branch are heavily polluted with raw or only partially treated sewage from inadequate treatment facilities and/or dilapidated collection systems. The data indicate that the Marr Branch station was the most grossly polluted of all tributary stations sampled during the study.

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INTRODUCTION

New River Gorge National River(NRGNR) was established by the United States Congress in 1978 and placed under management of the National Park Service (NPS) of the United States Department of the Interior. Title XI of the National Parks and Recreation Act of 1978 (Public Law 95-625) set aside a 62,000 acre corridor along 52 miles of New River "...for the purpose of conserving and interpreting the outstanding natural, scenic, and historic values and objects in and around the New River Gorge and preserving as a free-flowing stream an important segment of the New River in West Virginia for the benefit and enjoyment of future generations...". In order to fulfill this purpose the NPS is establishing a natural resource data base upon which it can frame the future of the National River. Obviously water resources are an important part of the information base. Recognizing this, the NPS since 1980 has conducted water quality research on streams within the National River's boundary. From 1980 through 1984 general water quality sampling was done by the West Virginia Department of Natural Resources (WV DNR) on a contractual basis for the NPS. In 1985 and 1986 the NPS conducted fecal coliform bacteria surveys without the assistance of the WV DNR, but in 1987 and 1988 the NPS joined again with the WV DNR in a cooperative agreement to carry out the bacteria surveys. Also in 1988 an agreement for conducting three general water quality samplings and one priority pollutant sampling, all to be carried out during 1988 and 1989, was made with the WV DNR. The purpose of this report is to publish data from the fecal coliform bacteria surveys done in 1987 and 1988. A later report will include the general water quality data collected from 1980 through 1984 and the bacteria data collected by the NPS in 1985 and 1986. The data generated from the general water quality and priority pollutant samplings in 1988 and 1989 will be published in a report in 1990. Because sampling and analytical methods used by the NPS in 1985 and 1986 were quite different from those used by the WV DNR in 1987 and 1988, no attempt is made to correlate the two data sets. Studies have shown that the different methods used sometimes give vastly different results. Indeed in 1986 samples split between the NPS and the WV DNR showed great discrepancy. Therefore the NPS-generated data is not included in this report.

One purpose of the bacteria surveys conducted in 1987 and 1988 was to determine which parts of the New River mainstem and which of several important tributaries located within the NRGNR boundary were in violation of the fecal coliform bacteria criterion of the West Virginia Water Resources Board during the main water-contact recreation season. The criterion is stated thus, "Maximum allowable level of fecal coliform content for Primary Contact Recreation (either MPN of MF) shall not exceed 200/100 ml as a monthly geometric mean based on not less than 5 samples per month; nor exceed 400/100 ml in more than ten percent of all samples taken during the month." Another purpose of the studies was to determine if patterns in bacteria contamination associated with flow regimes and seasonal variations existed.

OVERVIEW OF THE NEW RIVER GORGE NATIONAL RIVER AREA

The headwaters of New River are located in northwestern North Carolina in the southern Appalachian Mountains. From Blowing Rock, North Carolina, New River flows generally in a northward direction across southwestern Virginia before it enters southern West Virginia 163 miles from its source. The river continues flowing northward for 87 miles in West Virginia to Gauley Bridge where it joins Gauley River and forms the headwaters of Kanawha River. From New River's headwaters to Nitro, West Virginia New/Kanawha River's course follows that of ancient Teays River which began forming as the southern Appalachians rose out of an ancient ocean. Often touted as one of the oldest rivers in the world, perhaps second in age only to the Nile, New River's age is actually subject to much uncertainty. Age estimates range from 3 to 320 million years ago and the true age is probably no greater than any of the other rivers which head up in the southern Appalachian Mountain range in the vicinity of New River's source (Lessing, 1986). Mountain uplift and subsequent erosion have exposed many types of rock in the basin, but most typical are shales, sandstones and limestones. On its journey to the gorge, New River passes through extensive limestone karst areas and it gathers water from other streams which drain these calcareous lands also. Consequently New River is a well-buffered, biologically productive stream where it flows through the boundary of NRGNR. Presently the boundary encompasses New River from Hinton to the head of Hawks Nest Lake near Fayetteville. The boundary was changed slightly in 1988 so that the stretch of river now managed by the NPS is 53 miles while the land within NPS oversight is 62,660 acres.

The river is not truly a free-flowing stream within the gorge since the Army Corps of Engineers regulates the discharge through Bluestone Dam which impounds the river at Hinton just above the upstream boundary of NRGNR.The main purpose for which the dam was constructed is flood control, therefore the flow of New River rarely is as great during peak runoff as it would be under free-flowing conditions. Water quality is affected by the impoundment. Dilution or concentration of pollutants can occur through flow regulation. Indeed, during the drought conditions prevalent in West Virginia in 1988, the Bluestone discharge was used to dilute oxygen-demanding constituents in Kanawha River where it flows through the heavily industrialized portion of Kanawha Valley. Low flow augmentation is a rare use of the dam discharge. If not for the extreme drought conditions in West Virginia and the more normal precipitation events which occurred in the upper New River watershed in Virginia and North Carolina, Bluestone Reservoir would not have been used for that purpose in 1988.

In the New River watershed many sources contribute oxygen-demanding compounds, nutrients and pathogenic organisms. Sediment may be added by runoff from construction sites and farm lands. Farms may also contribute herbicides, pesticides and nutrients, while biocides sprayed on powerline or pipeline rights-of-way may end up in New River and its tributaries via storm runoff. Direct applications of pesticides into streams, such as occurs with the black-fly control program, may be sources of contamination also. Improper waste disposal by recreationists may also add nutrients and pathogens to streams especially at areas of

congregation such as rafting lunch sites and horseback riding corral sites.

During the first coal boom in West Virginia, when the War Between The States was over and completion of the Chesapeake and Ohio railroad opened the New River valley to numerous coal interests, boom towns popped up along the river and the population of the gorge was swollen by thousands of impoverished southerners looking for work. This cheap labor force poured into the gorge area and no doubt placed a heavy domestic waste burden on New River. However, the river acted as a fine sewer since it was well oxygenated and relatively fast flowing so that wastes were carried quickly away out of sight, out of smell, and out of mind to be decomposed by the myriad organisms inhabiting the water column and substrate. Coal booms came and went and as mines played out along the gorge walls, new mines opened further up the river's tributaries and in other areas of southern West Virginia where the Norfolk and Western rail system had rapidly expanded. The population decline within New River Gorge undoubtedly decreased the sewage load which the river had to handle. President Lyndon Johnson's Great Society programs and creation of the Appalachian Regional Commission poured federal funds into West Virginia and many sewage treatment facilities were built in the 1960's decade. Passage of the Federal Water Pollution Control Act amendments of 1972 provided more funding for upgrading existing municipal wastewater treatment plants and for constructing new facilities. There may be less of an impact from sewage in New River now than there has been since the 1920s, but with a recent population surge in the areas around Beckley, Oak Hill and Fayetteville, and only minimal upgrading of old plants and collection systems, New River could experience some degradation in water quality in the next few years. Several sewage treatment plants (STPs) in the NRGNR watershed are overloaded and suffer from infiltration/inflow (I/I) problems in their collection systems. Consequently overflows of sewage at manholes, lift stations and STPs are frequent in certain tributary watersheds.

Prior to establishment of NRGNR, the river was becoming a popular recreation corridor especially for rafters, kayakers and anglers. Since NRGNR was created, recreational activities have increased greatly. The potential for human exposure to water-borne pathogenic organisms has therefore increased substantially. This is due less to an increase in sewage than to an increase in the number of recreationists exposed to the pathogens already present in New River and its tributaries. The increased potential for human health risks associated with untreated and only partially treated domestic wastewater discharges into streams flowing through NRGNR warrants investigation.

Presently, New River is a very productive stream in terms of species diversity and population levels of the biota found in it. The first links in the aquatic food chain are so numerous that the last links, represented by smallmouth and rock bass, and a few other species of predatory fish, are abundant enough to make the river one of the most popular fishing streams in West Virginia. Some human activities pose threats to the river's productivity. Sewage, livestock wastes and runoff from farms, construction sites,

and utility rights-of-way have already been mentioned. Intense forest fires like those that burned in southern West Virginia in 1987 may accelerate erosion and thus contribute sediment to New River and its tributaries at a much greater rate than normal. Fayette and Raleigh counties were burnt badly in 1987; 14,515 and 28,292 acres respectively. Drought conditions early in the year provided fuel for extensive wildfires even before the official fall fire season started on October 1. An 150 acre fire burned in Fayette County along New River outside the NRGNR boundary before September. The Forestry Division of the West Virginia Department of Agriculture estimated that 99% of the wildfires in the fall of 1987 were due to human activity and over half were due to incendiarism (Atkins, 1988). Coal mining has contributed heavily to the pollutant loads of several tributaries of New River. Acid water is not as much of a problem as is metal-laden water. High concentrations of aluminum, iron and manganese are generated from certain seams of coal within the NRGNR area. Several abandoned mines contribute large quantities of these metals to some New River tributaries. Drainage from old refuse piles associated with coal cleaning processes is another source of heavy metals. Along with all the activities mentioned above salting roads in winter, washing vehicles alongside drainage ditches, disposing of garbage in illicit dumps, timbering and numerous other activities can play a role in degradation of the streams in NRGNR. Monitoring projects such as those reported in this document are important tools in protecting those streams from abuse and restoring damaged streams to better conditions.

STUDY AREA

For the 1987 and 1988 fecal coliform bacteria studies conducted by the WV DNR for the NPS, lists of sampling points are found in Tables 1 and 2. Figure 1 shows the relative locations of the points. For the station codes in the figure and the tables, "N" denotes mainstem sites while "T" indicates tributary sampling points. The WV DNR and the NPS cooperated in selecting the sites, basing that selection on historical data, degree of water contact recreation and known problem areas. All sites are located within the boundary of NRGNR except for the sampling point at the NPS visitor center just below Bluestone Dam. Nine mainstem sites were sampled both years. In 1987 five tributary streams were sampled, but in 1988 one of these was discontinued while two others were added for a total of six tributary points sampled that year.

STUDY PERIOD

The period of April through September is a busy period for NRGNR since recreationists, especially the boaters, are most active during spring and summer. In a typical year spring runoff creates exciting whitewater or brownwater boating opportunities. In summer, weekday pace is slow, but weekends are crowded with rafters, kayakers, canoeists, anglers and swimmers pursuing their sports along New River. The sampling season coincides with the water recreation season and thus with the period during which the greatest number of people are exposed to New River's waters and its pathogens. Relatively normal flows in the spring of 1987 were followed by relatively low flows in tributaries of New River in the

Table 1. Mainstem Sampling Sites, New River Gorge National River Fecal Coliform Bacteria Studies, April-September, 1987 and 1988.

Station	River Mile	Side (Descending)	Year(s) Sampled	Location
N-1	64.1	Left	87-88	New River at Hinton NPS Visitors Center (area of direct downstream flow - no eddy)
N-2	60.9	Right	87-88	New River below Hinton Sewage Treatment Plant (direct downstream flow)
N-3	59.5	Left	87-88	New River 30 yds. below Brooks Falls (direct downstream flow)
N-4	55.4	Left	87-88	New River at Sandstone Falls (direct downstream flow)
N-5	50.8	Right	87-88	New River at NPS Access in town of Meadow Creek (no perceptible flow at low stages, eddy at normal to high stages)
N-6	38.6	Left	87-88	New River at McCreery NPS Access (direct downstream flow at high water; eddy, influenced by Piney Creek, at low to normal flows)
N-7	27.8	Left	87-88	New River at Stone Cliff Beach (direct downstream flow)
N-8	27.4	Left	87-88	New River at Thurmond NPS Access (direct downstream flow at normal to high levels; pool with little perceptible flow at low stages)
N-9	12.0	Left	87-88	New River at Fayette Station/South Fayette, 10 yds. above Wolf Cr. (eddy influenced by Wolf Creek)

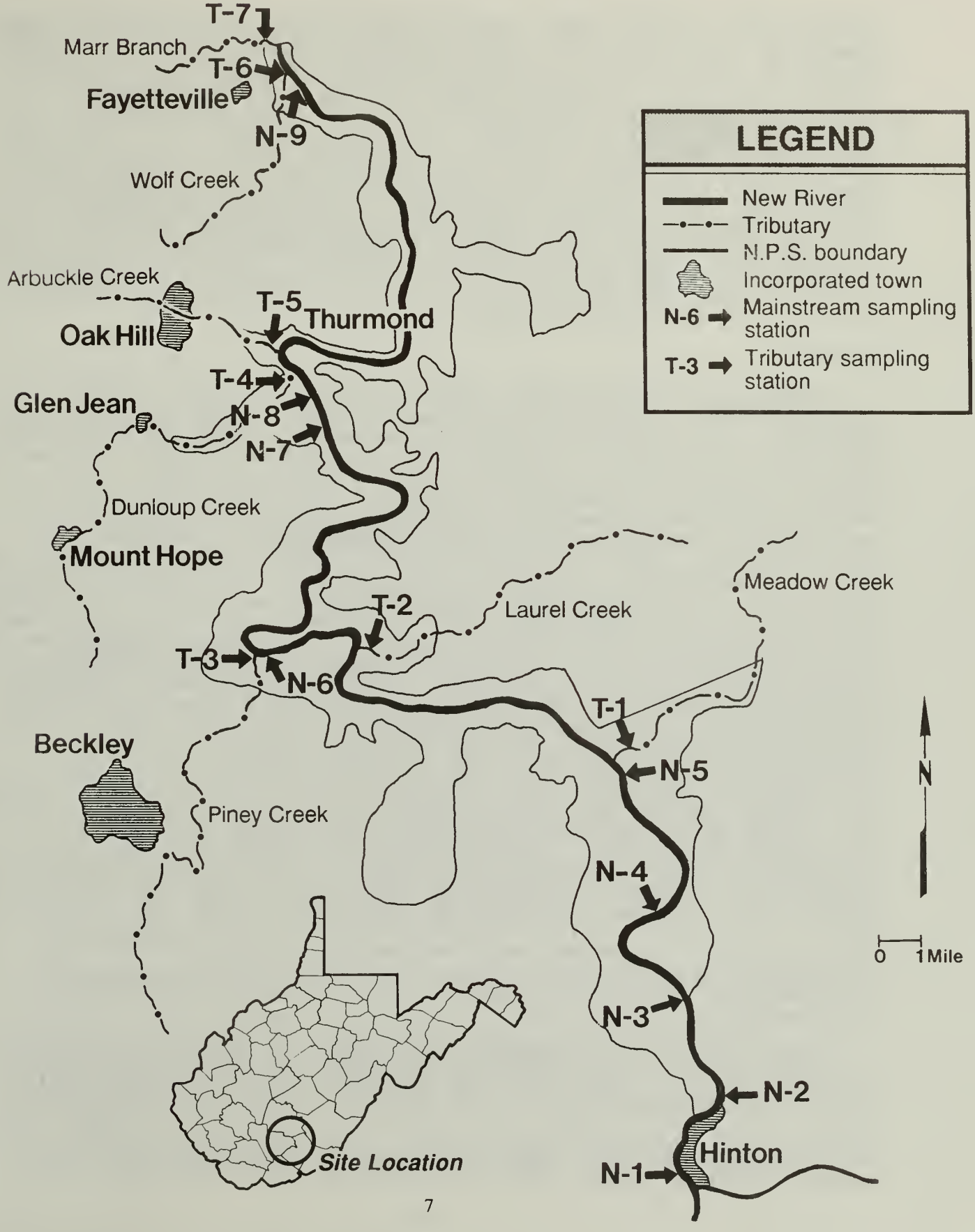
Table 2. Tributary Sampling Sites, New River Gorge National River Fecal Coliform Bacteria Studies, April-September, 1987 and 1988 (river mile and side refer to New River mile at mouth of tributary and side of river where tributary enters).

Station	River Mile	Side (Descending)	Year(s) Sampled	Location
T-1	50.2	Right	87-88	Meadow Creek near mouth (at Rt. 7/1 bridge)
T-2	41.6	Right	87	Laurel Creek near mouth (at cabled logging road crossing)
T-3	38.5	Left	87-88	Piney Creek at mouth
T-4	26.2	Left	87-88	Dunloup Creek near mouth (between bridges on secondary Rt. 25)
T-5	25.5	Left	88	Arbuckle Creek at mouth
T-6	11.9	Left	87-88	Wolf Creek at mouth
T-7	11.0	Left	88	Marr Branch below Rivers, Inc. campground

Figure 1

Map of New River Gorge Fecal Coliform Study Area

April - September, 1987-1988



summer. The flow of the river mainstem remained relatively normal throughout the summer as regulated by the discharge from Bluestone Reservoir. Unusually low precipitation throughout West Virginia marked the period from the summer of 1987 through the summer of 1988. Low tributary flows in spring, 1988 were followed by extremely low flows in summer. The river mainstem was lower than normal also, but previous winter and spring precipitation in the mountains of North Carolina and southwestern Virginia was higher than in West Virginia so that Bluestone Reservoir was at the normal spring pool level. Higher rainfalls in the upper New River watershed in Virginia and North Carolina throughout 1988 ensured that New River had a flow closer to normal than other rivers in West Virginia during the duration of the drought. There was enough inflow to the reservoir to allow low flow augmentation downstream during a few days in September.

METHODS

Fecal coliform bacteria (FC) are commonly found in the digestive tracts of all homeothermal animals. They can live and reproduce only temporarily once excreted with fecal material from the gut of an animal. The survival time and the length of time in which the reproductive function remains viable outside of an animal's digestive tract are variable. Cold, anaerobic, aquatic environments are suitable to survival while warmer aquatic environments may be suitable for reproduction but decrease the survival time. Fecal coliform bacteria are not pathogenic, but they do give a convenient measure of the possible occurrence of disease agents within water samples. Some pathogens may survive conditions unsuitable to FC while others may die under conditions which favor the survival of FC outside of the gut. Therefore the reader should understand that FC are indicator organisms only and under some conditions they are not very good indicator organisms. The best studies concerned with sewage pollution utilize other parameters along with FC to determine the extent of pollution. Occasionally a filthy stream will have very low FC counts while nitrogen, phosphorus and biochemical oxygen demand are very high. For instance this may occur in a stream where slow moving water, heated by exposure to the sun, is not suitable to survival of FC. The FC test alone would indicate no problem even though the stream is overloaded with sewage. On the other hand, bacteria counts in the thousands are almost always indicative of concentrated domestic or animal waste sources. Typically, higher counts are interpreted as indicative of higher human health risks; the larger the count, the greater the risk. In the studies conducted for the NPS in 1987 and 1988, no other parameters were tested for, so the FC data are interpreted only in the light of visual and olfactory observations and knowledge of possible sources of fecal pollution within the study area.

Each location was sampled five times per month during the six month period from April through September for a total of thirty samples per site each year. All but one of the mainstem sampling points are located along the shoreline at sites where human exposure to the water is extensive, e.g. boat put-in/take-out points maintained by the NPS. The site directly downstream of Hinton's sewage treatment plant (STP) is the exception. Tributary samples

were collected from the streams' banks. All of the tributaries are well mixed at the sampling points. Hand-held, 100 ml plastic bottles were used to collect the samples. Prior to use the bottles were sterilized and spiked with a small amount of sodium thiosulfate used to bind residual chlorine. Chlorine is not often found in streams, but in order to meet the requirements of Method 906A of the 16th edition of Standard Methods (1985) the fixative was added after sterilization. Following sample collection, the bottles were iced in a cooler and delivered to the Water Resources laboratory in Charleston within six hours. Analysis was by the Membrane Filter Method (Method 909C in Standard Methods). Results are reported as fecal coliform bacteria colonies (counts) per 100 ml of sample. Results for each site are summarized as monthly geometric means, identically calculated by either of the two following formulas:

$$GM = \sqrt[n]{[(FC1)(FC2)\ldots(FCn)]}$$

or

$$GM = 10^{\left[\frac{(\log FC1) + (\log FC2) + \ldots(\log FCn)}{n}\right]}$$

where GM = monthly geometric mean.

FC1, 2...n = fecal coliform bacteria value for sample number 1, 2...n.

n = total number of samples during month (5 in all cases).

In cases where fecal coliform could not be precisely quantified, laboratory personnel expressed results in terms of "greater than" or "less than" a specific level, e.g. <10 or >20,000. In those cases, the numbers accompanying the "greater than" or "less than" symbols were used in the monthly geometric mean calculations, since they were the best approximations available. For example, if a reported value was "<10", the value of "10" was used in calculations. Tables 3 and 4 in the Appendix indicate where values could not be precisely quantified for the data. Monthly geometric means were calculated in order to determine whether or not the streams were meeting the first part of the standard established by the West Virginia Water Resources Board for protection of recreational use and public water supply, i.e. 200 counts/100 ml expressed as a geometric mean based on no less than five samples per month.

Occasionally throughout the report flow levels are referred to as high, normal or low. These categories are based upon the opinion of the sampler rather than on quantifiable data. While subjective, his opinion is nonetheless drawn from several years of familiarity with the streams in this study. For the purpose of this report, a subjectively derived flow will suffice in discussing the results, although actual flow measurements are preferred.

In the conclusion, supposed relationships between FC data

generated in this study and particular sewage treatment works are discussed. Information given about the treatment facilities is based upon results of compliance evaluation inspections and compliance sampling inspections conducted by Division of Water Resources personnel, and on conversations with personnel in the Permits and Construction Grants branches of the division.

RESULTS AND DISCUSSION

Individual data for all samples collected during the 1987 and 1988 studies are presented in Tables 3 and 4 in the Appendix. Figures 2 through 17 present the monthly geometric means by station for both 1987 and 1988.

N-1, New River at Hinton NPS Visitors Center (Figure 2):

This site is on the left side of the river about 1 mile downstream of Bluestone Dam. There are no streams entering New River between the dam and the sample point. Greenbrier River water never reaches the site even during flood stage. Although the tributary enters New River a short distance above the sample point, the confluence is on the opposite side. The Visitors Center location was chosen as a control site since it fairly well represents direct discharge from the reservoir. Also, public access to New River is provided by the NPS there so, as in most other main-stem sites chosen for this study, the potential for human exposure to water-borne pathogens which might be found in the river was considered great.

FC concentrations at N-1 were relatively low both years with the only violation of the 200 counts/100 ml part of the criterion occurring in April of 1987; the geometric mean was 296. The lower geometric means for April and May in 1988 compared to those in 1987 may indicate the effect of drought conditions on decreasing surface water runoff during that normally wet period. A lack of rainfall in the spring of 1988 might have kept FC from entering New River from the mountainside between the dam and N-1. The only violations of the 400 counts/100 ml portion of the standard detected during the study were in April and May of 1987. The violation in May was due to one concentration of 700. A value of 900 was the cause of violation in April. As mentioned previously, N-1 in April also experienced a violation of the geometric mean part of the criterion. The low FC levels at this site are probably indicative of a low human health risk.

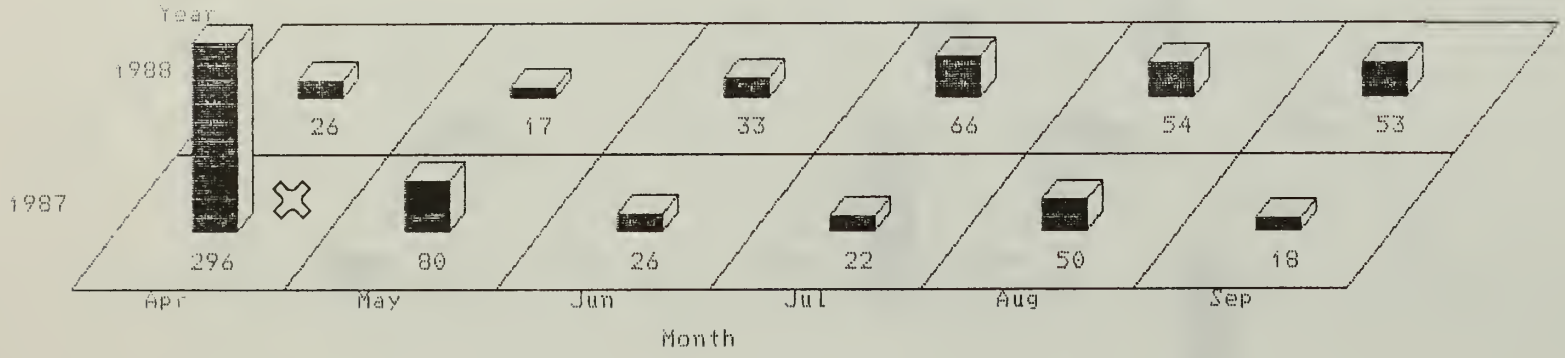
N-2, New River below Hinton STP (Figure 3):

The location of this sampling point is just 30 yards below the discharge from Hinton's STP. This antiquated, overloaded plant rarely discharges an effluent which meets permit limitations. Heavy growths of sewage fungi in the water along New River's bank were persistent at the sampling location. The odor was sometimes sickening to the sampler. Violations of the 200 counts/100 ml FC stream standard occurred at N-2 every month sampled in 1987 and 1988. Concentrations of individual samples in the tens of thousands were not uncommon and several counts greater than 100,000 were obtained both years. The two highest levels detected for individual

Figure 2. **New River Gorge National River Fecal Coliform Survey**

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=N-1 Name of Site=New R. Hinton NPS

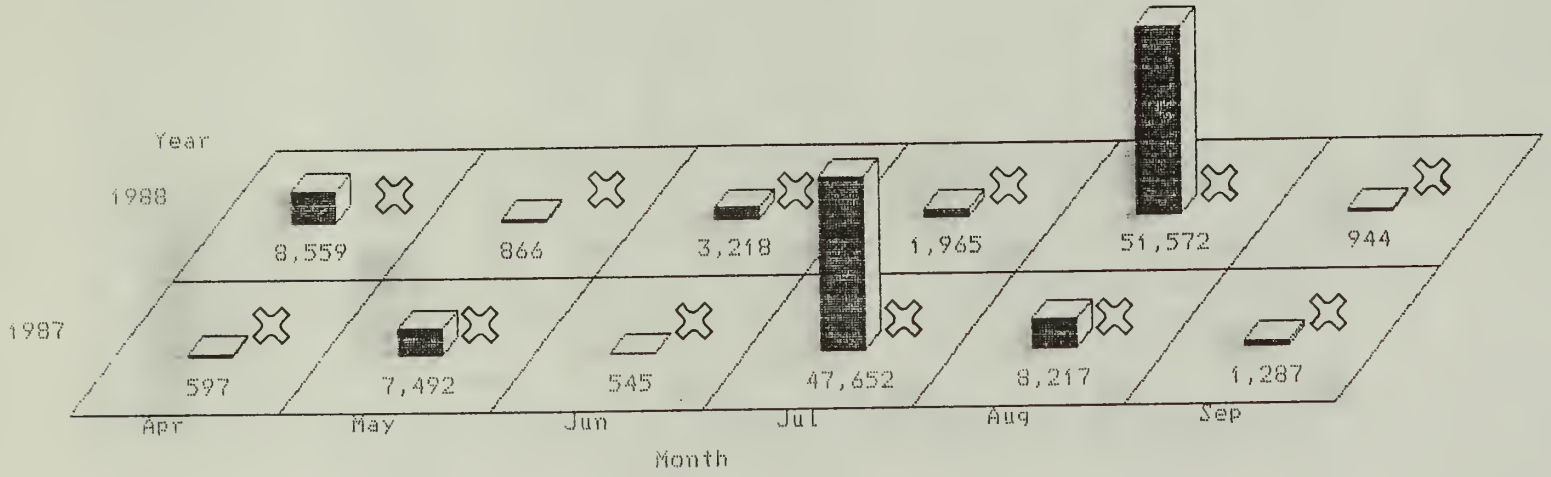


MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliliters of Water

⛒ Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=N-2 Name of Site=New R. Hinton STP



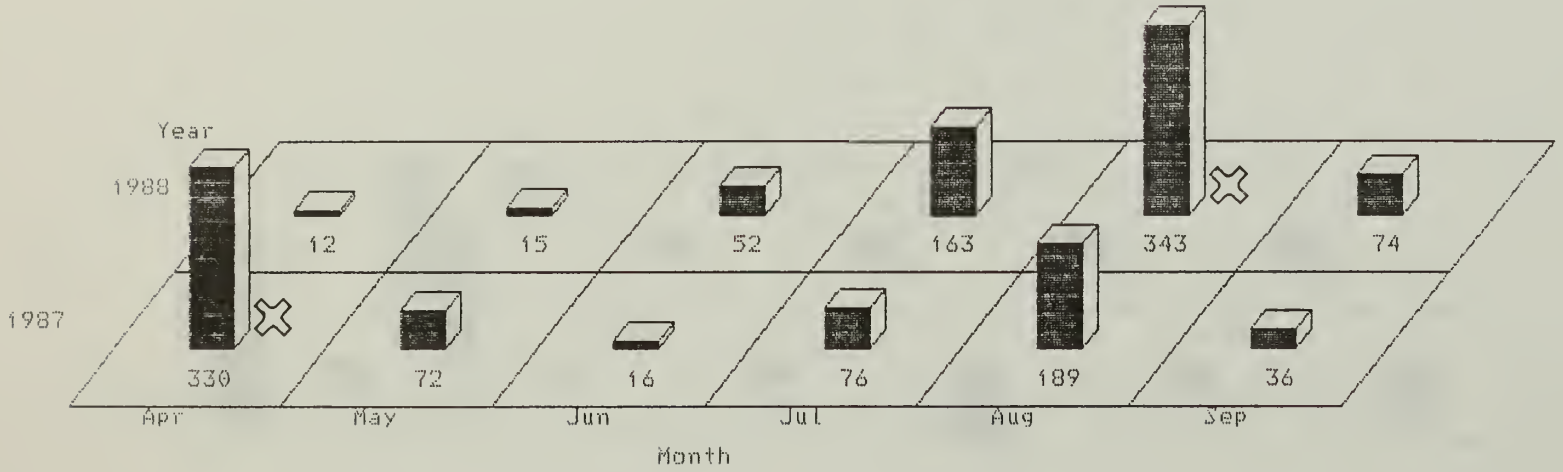
MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

⛒ Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 4. **New River Gorge National River Fecal Coliform Survey**

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=N-3 Name of Site=New R. Brooks Falls



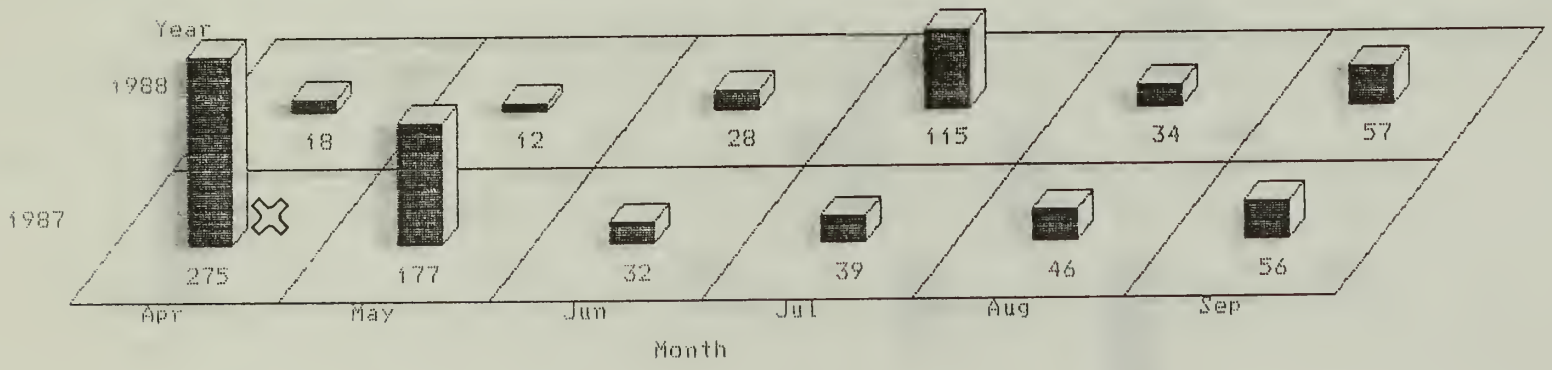
MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

⛒ Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 5. New River Gorge National River Fecal Coliform Survey

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=N-4 Name of Site=New R. Sandstone



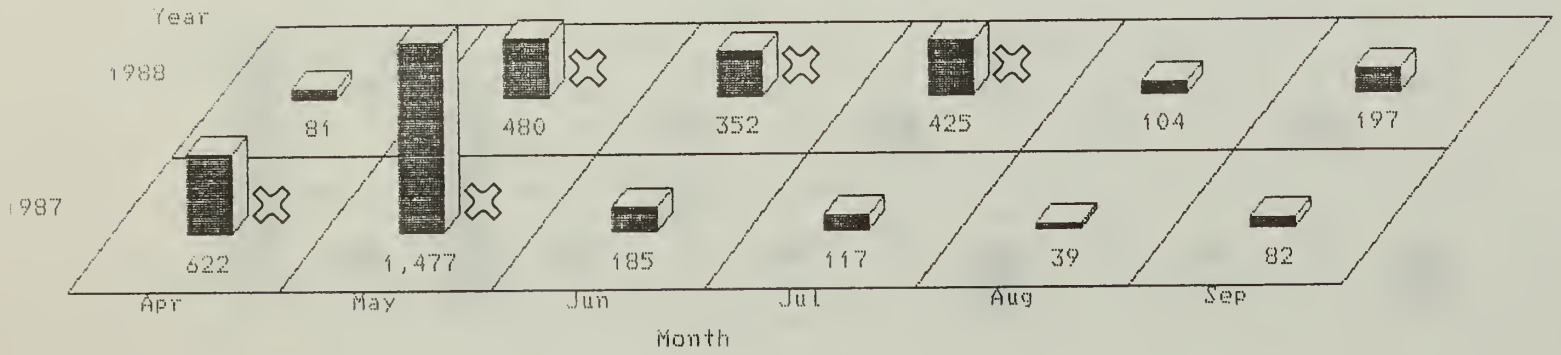
MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

⊠ Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 6. **New River Gorge National River Fecal Coliform Survey**

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=N-5 Name of Site=New R. Meadow Ck



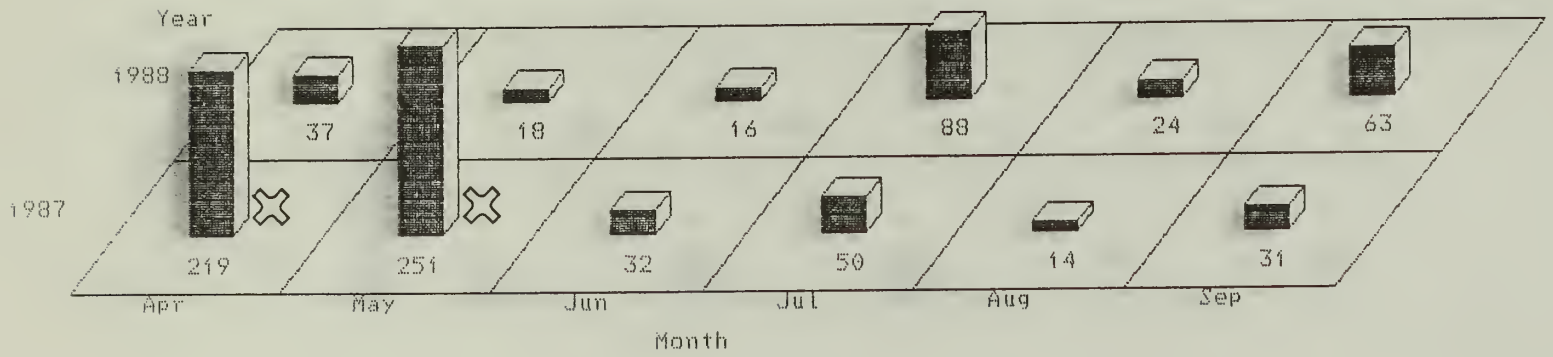
MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 7. New River Gorge National River Fecal Coliform Survey

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=N-6 Name of Site=New R. McCreery



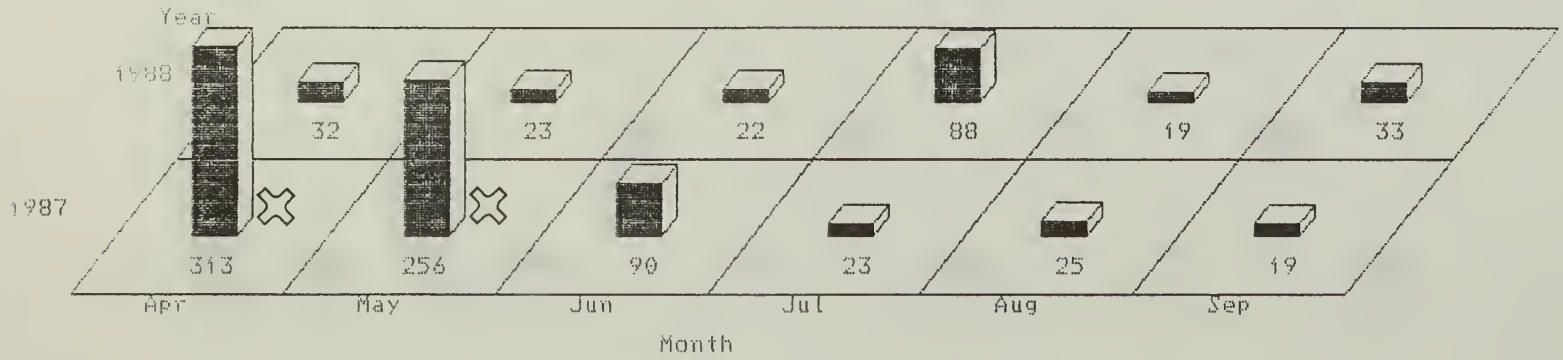
MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

⛒ Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 8. **New River Gorge National River Fecal Coliform Survey**

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=N-7 Name of Site=New R. Stonecliff



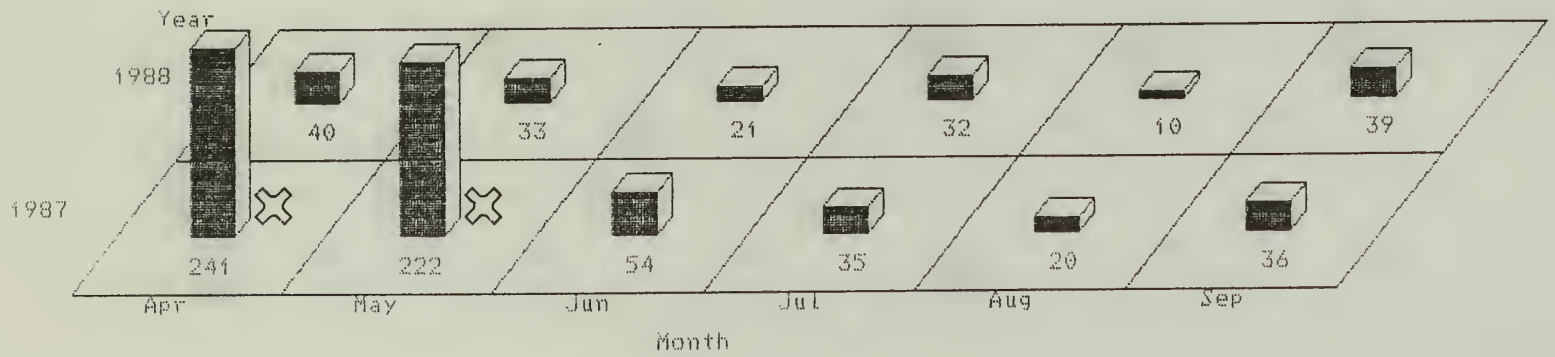
MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

⛒ Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 9. New River Gorge National River Fecal Coliform Survey

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=N-8 Name of Site=New R. Thurmond



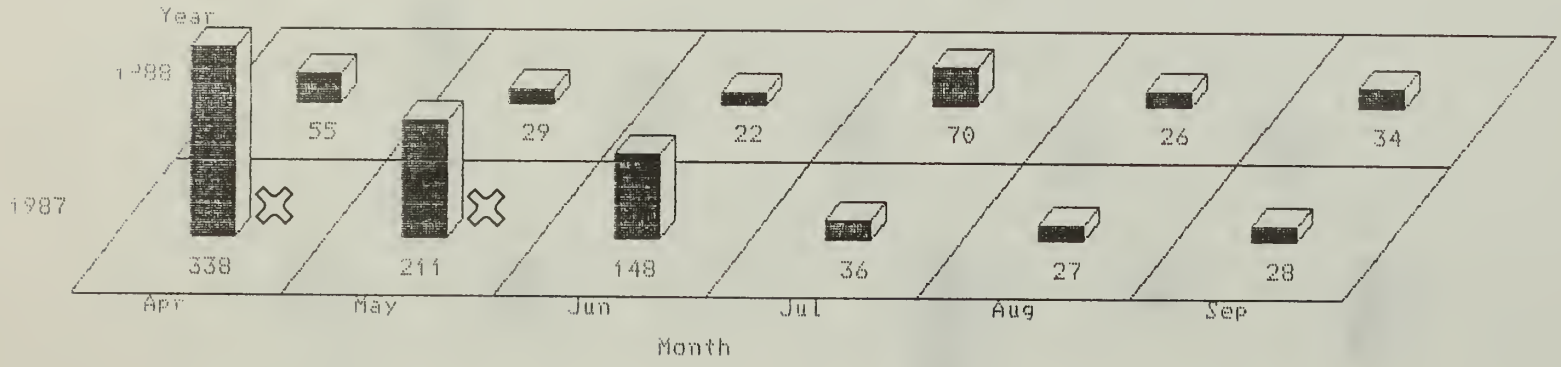
MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

⛒ Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 10. **New River Gorge National River Fecal Coliform Survey**

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=N-9 Name of Site=New R. Fayette



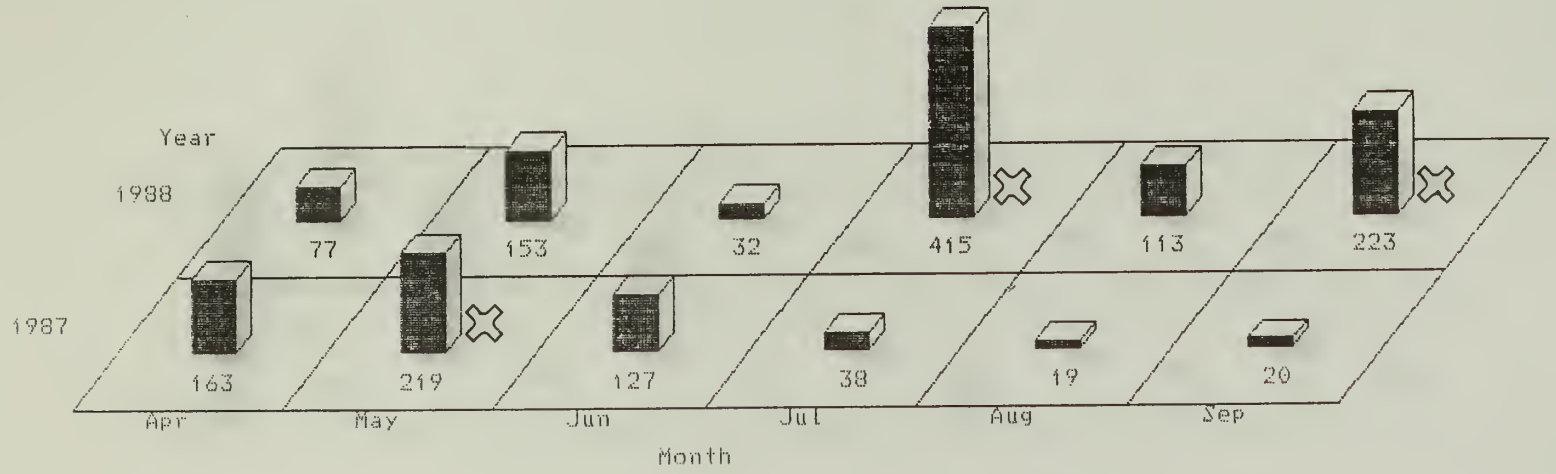
MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

⛒ Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 11. New River Gorge National River Fecal Coliform Study

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=T-1 Name of Site=Meadow Ck.



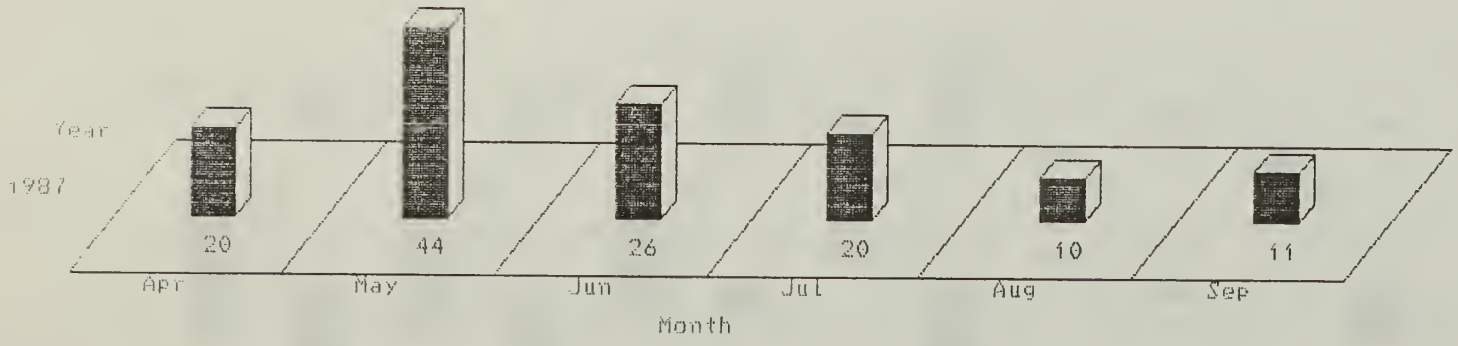
MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

⛒ Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 12 **New River Gorge National River Fecal Coliform Survey**

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=T-2 Name of Site=Laurel Ck.



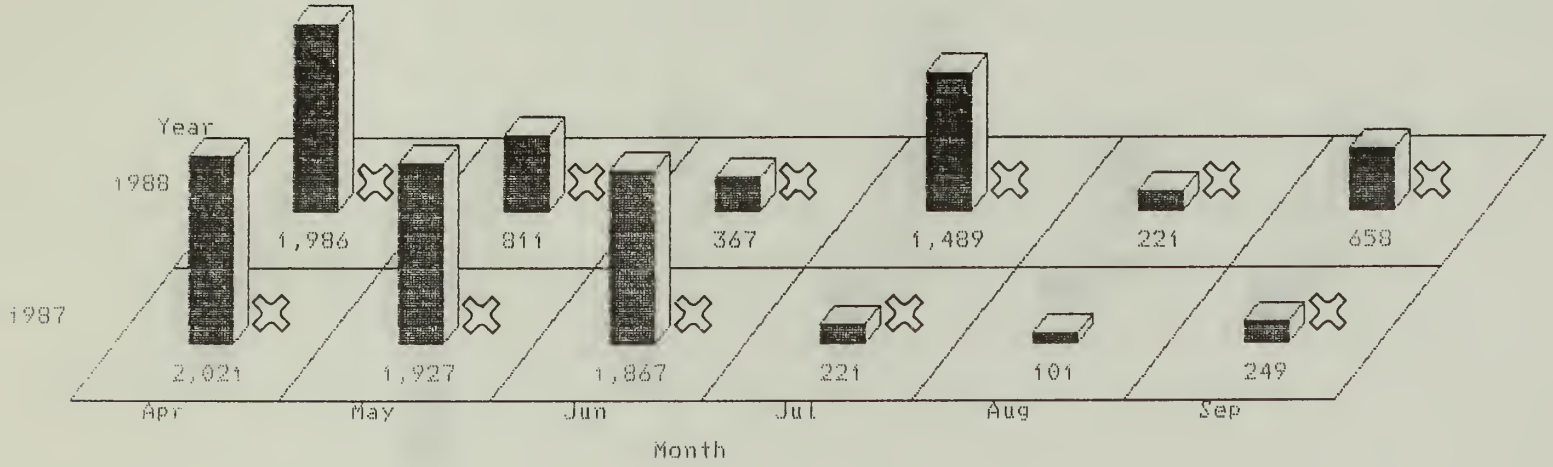
MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 13. New River Gorge National River Fecal Coliform Survey

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=T-3 Name of Site=Piney Ck.



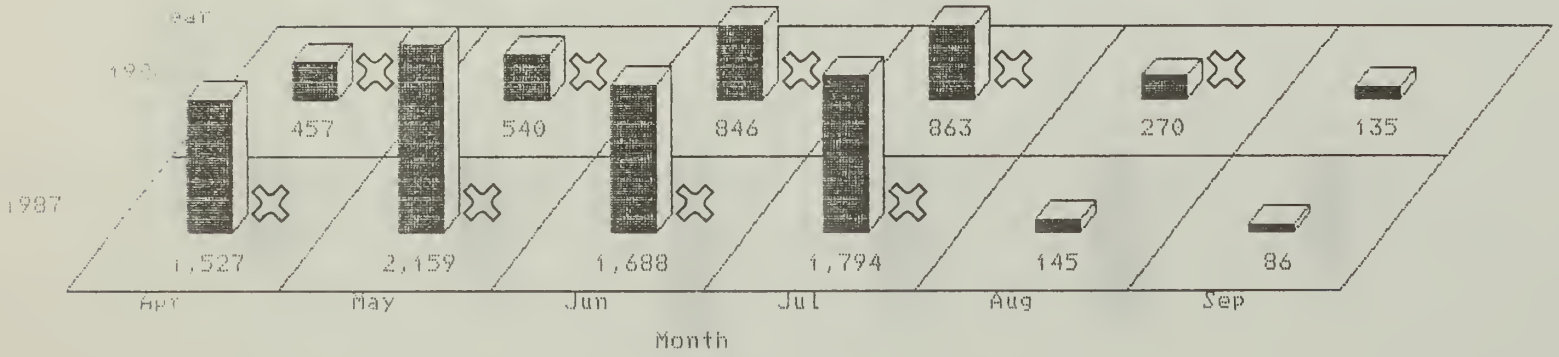
MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

⛒ Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 14. **New River Gorge National River Fecal Coliform Survey**

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=T-4 Name of Site=Dunloup Ck.



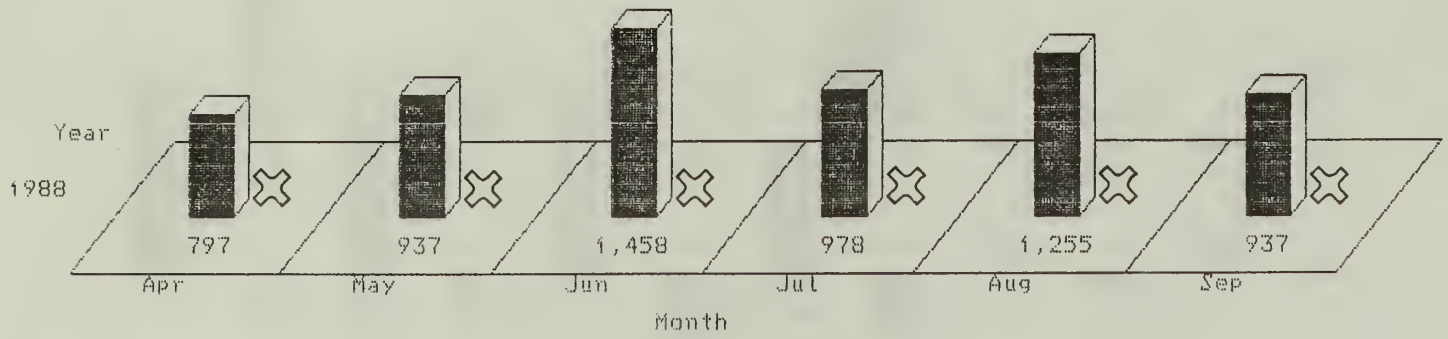
MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 15. New River Gorge National River Fecal Coliform Survey

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=T-5 Name of Site=Arbuckle Ck.



MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

⛒ Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 16. **New River Gorge National River Fecal Coliform Survey**

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=T-6 Name of Site=Wolf Ck.

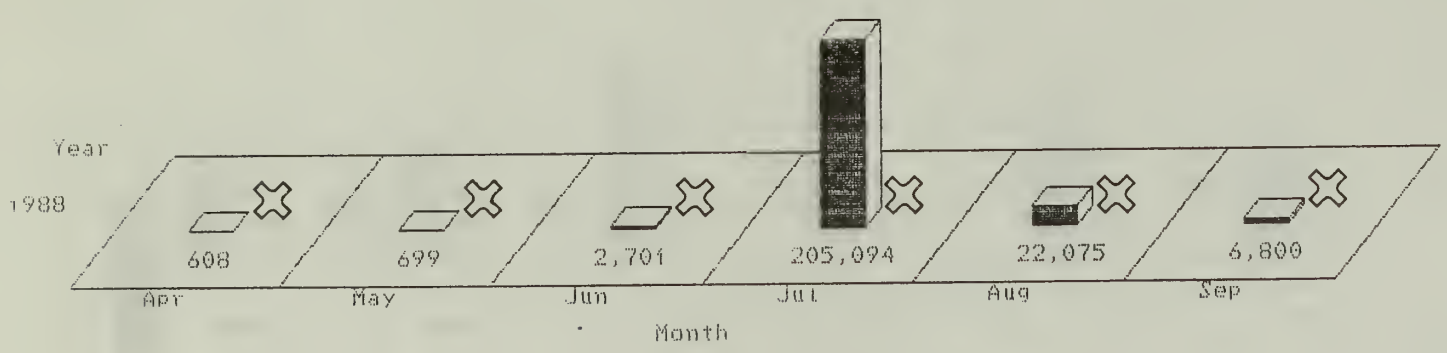
MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliters of Water

⛒ Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

Figure 17. New River Gorge National River Fecal Coliform Survey

Monthly Geometric Means of Fecal Coliform, MF/100ML during the Recreational Periods for the Years 1987 and 1988

Fecal Sampling Site=T-7 Name of Site=Marr B.



MF/100ML = Counts of Colonies in Membrane Filter per 100 Milliliters of Water

⛒ Indicates that the geometric mean exceeds the 200 counts/100 ml criterion.

samples, >314,000 and 400,000 occurred in 1988, but two readings of >300,000 were obtained in 1987. Effects of the drought in 1988 are not apparent at N-2. Great fluctuations in FC concentrations at that site were probably due to differences in dilution at various river flows and varying degrees of treatment efficiency of the STP at different volumes of influent. Stormwater overloads the facility at times and occasionally a break in the culvert which drains the drying beds into a manhole allows the filtered wastewater to leak into a small stream that empties into New River just below the STP discharge. The highest geometric mean obtained was 51,572 in August, 1988.

N-3, New River at Brooks Falls (Figure 4):

This sampling site is located just below Brooks Falls on the left bank of the river. This is opposite and less than 3 miles downstream from the Hinton STP. It is unlikely that bank-to-bank mixing occurs in this distance so the discharge at the plant is not considered a factor in FC levels at N-3. In 1987 two peaks were indicated at N-3, the highest was in April at 330 (the only geometric mean in 1987 greater than 200) and the second was in August at 189. No spring peak was seen in 1988, due likely to the abnormally low flow conditions, but a peak did emerge in August. At 343 this peak in the monthly geometric mean was the only violation of the geometric mean portion of the standard to occur at N-3 in 1988. Apart from the months in which the geometric means were above the standard, only July, 1988 exhibited a violation of the second part of the criterion; 650 on July 12. While flows in New River were not extremely low during the drought period as they were in other West Virginia streams, the levels were nonetheless lower than normal. If the two August peaks represent a pattern, it is likely due to a source of sewage not far above Brooks Falls. A cluster of residences and summer camps is located in a broad bottom less than 1.5 miles upstream of Brooks Falls. The summer population in that area is greater than the spring population and if sewage treatment is inadequate, direct discharges to New River might increase during the same period in which the river is at its lowest flow. Many unregulated streams are lowest in September and October. Winter drawdown often begins in those months at flood control reservoirs, therefore August is typically the low flow month in streams which drain such reservoirs. The combination of low flow and increased sewage discharges could cause FC levels to peak in August as they did at Brooks Falls in both years of this study. However, until more information is available, this explanation is only a speculation with several uncertainties attached. The relatively low FC levels may not warrant intense study.

N-4, New River at Sandstone Falls (Figure 5):

This sampling location is about 7 miles downstream of the Hinton STP. It is on the opposite bank and above the constriction of Sandstone Falls.Due to several factors in the river segment between the STP and the falls, the likelihood of detecting FC from the STP at N-4 is minimal. Poor lateral mixing, dilution of the effluent by New River, aerobic conditions in the river and the great length of that segment all lessen the chances of survival of FC.

Unlike spring FC levels in 1987, those in 1988 were not higher than in the rest of the sampling period. Just the opposite happened. FC concentrations in April and May of 1988 resulted in geometric means for those months which were lower than the geometric means in the remaining months. The higher spring levels in 1987 resulted in one violation of both parts of the criterion in April (geometric mean was 275), while the relatively low levels throughout the 1988 sampling period resulted in no violations of the geometric mean portion of the standard. The 400 counts/100 ml part of the criterion alone was exceeded in May of 1987 (440 and 480) and July of 1988 (1,650). The unusual pattern of FC concentrations at Sandstone Falls in 1988 is indicative of the effect of the drought. Several seasonal residences are located about 1.5 miles upstream of N-4. If those structures have direct discharges of human waste, then their increased usage in summer could contribute to elevated FC concentrations at Sandstone Falls. Other possible sources of higher levels during lower flow periods are the geese which frequent the shallows above the falls.

N-5, New River at Meadow Creek (Figure 6):

Located a short distance downstream of the town of Meadow Creek's STP, this sampling point is a public access site maintained by the NPS on private property. Except during high flows, samples collected here are not very representative of the mainstem's water column because of the site's location in an eddy. During the lowest flow period of 1988 there was no detectable movement of the water except that caused by wind. Ducks frequent the sampling station and defecate ubiquitously while they feed and rest.

In 1987 violations of both portions of the stream standard occurred in April and May. Geometric means were 622 and 1,477 respectively. These high values along with the lower values obtained in the remainder of the sampling season are typical of streams with normal spring runoff and lower flows in summer. However, this pattern was not demonstrated in 1988. High individual counts, such as the >30,000 figure obtained on July 12, can be directly tied to the days that fresh duck feces were abundant at the site. The sewage treatment facility at Meadow Creek is a well-run plant with minimal operation problems. It is doubtful that the effluent contributed high FC to New River during the low flows of 1988. The geometric means of May, June and July in 1988 were 480, 352 and 425 respectively. These violations of the stream standard are likely due to the duck activity prevalent at N-5. The second portion of the criterion was violated during those months also. The latter part of the standard was also exceeded in June (450 and 620), July (470) and September (3,300) of 1987, andAugust (540) and September (440) of 1988. So in four out of five months of each year's sampling period, the FC criterion was violated.

N-6, New River at McCreery (Figure 7):

This station is a public access site maintained by the NPS on private property located at the mouth of Piney Creek. The sampling point is just a few yards upstream of the creek in an eddy. Only during high flows is the eddy not present. It is thought that Piney

Creek's FC levels may have influenced the levels found in the eddy at N-6, but even when the creek's FC concentrations were extremely high, the levels in New River at N-6 were usually much lower. The geometric means in 1987 showed a typical pattern of higher values in spring compared to summer while in 1988 the means at N-6 were similar to those at N-1, N-3 and N-4, i.e. higher in summer than in spring. No violations of the 200 counts/100 ml geometric mean portion of the FC standard occurred at the McCreery site in 1988 even though Piney Creek was in violation every month it was sampled. Two violations occurred in 1987 at N-6; 219 in April and 251 in May. The 400 counts/100 ml part of the criterion was also exceeded during those months. Usually, high individual sample concentrations of FC at N-6 were associated with very high levels in Piney Creek supporting the hypothesis that Piney Creek water influences the sample point. The second part of the criterion alone was exceeded once in July of each year (450 in 1987 and 1,100 in 1988).

N-7, New River at Stone Cliff (Figure 8):

This sampling location is at a popular recreation spot above the town of Thurmond. Many rafters and other boaters intent on experiencing the challenge of lower New River's whitewater put-in at this beach. Rafting companies move rocks in order to maintain a side channel from the shallows to the main channel. Anglers and swimmers also enjoy the river at this site.

The pattern of FC concentrations seen in 1987 at N-1, N-3, N-4, N-5, N-6, N-8 and N-9 was also noted at N-7. The only violations of the 200 counts/100 ml part of the stream standard were 313 in April and 256 in May. The second part of the criterion was also exceeded in those months. The geometric means for July, August and September were very low. In 1988 all the geometric means were lower than the standard. Each month except July exhibited a mean between 19 and 35 while July had a geometric mean of 88. Two violations of the 400 counts/100 ml portion of the FC criterion alone occurred in each year. In 1987 one violation was detected in June (2,400) and one in August (460). Concentrations of 620 in May and 1,430 in July were the violations found in 1988.

N-8, New River at Thurmond (Figure 9):

This site is located at an access point maintained by the NPS above most of the development in Thurmond. Only a few seasonal dwellings are located immediately upstream of this point. During low flow the movement of water past the sampling site is sometimes imperceptible since it lies on the shallow side of a broad area in a pool. The access area is popular with some rafting companies. Several other rafting companies maintain their own put-in points in the vicinity of N-8.

As with the other mainstem sites (except N-2) in 1987, N-8 exhibited its highest monthly geometric means of FC in spring; 241 and 222 in April and May respectively. Both portions of the FC stream criterion were exceeded in those months. No other violations of the geometric mean standard of 200 counts/100 ml occurred the rest of the sampling period, however the second portion of the criterion alone was exceeded once in June (1,900) and once in

September (1,040). In 1988 no pattern was evident. Monthly geometric means ranged from 10 in August to 40 in April. The only violation of the second part of the criterion in 1988 was 430 on September 20.

N-9, New River at Fayette Station/South Fayette (Figure 10):

The beach at South Fayette above the Fayette Station rapid is a popular recreation spot. Anglers fish in New River and Wolf Creek there, campers and picnickers utilize the beach, swimmers take advantage of the deep hole of water there, and boaters take-out and put-in at the beach. An eddy current at low flows appears to carry Wolf Creek's water to the sampling point and thus it may affect FC concentrations at that site. High FC levels in the spring of 1987 reflect the pattern found at most other mainstem and tributary sites. At 338 and 211, respectively, the April and May geometric means were the only violations of the 200 counts/100 ml part of the criterion detected at N-9 in 1987. The 400 counts/100 ml portion of the standard was also exceeded in those months. That part of the standard alone was exceeded once in June (2,000) and once in August (740) in 1987. In 1988 no violations of the first part of the standard were found. Like N-1, N-4, N-6 and N-7, New River at South Fayette in 1988 exhibited its highest monthly geometric mean in July at 70 counts/100 ml and this was due to the one concentration (760) observed which exceeded the second portion of the stream criterion. As with most of the other mainstem sites, the relatively low concentrations detected in spring were probably due to the abnormally low flows in April and May of 1988. While Wolf Creek may contribute high concentrations of FC to N-9 in a typical spring, during the summer portion of the study period it often discharged lower FC levels into New River than were already present.

T-1, Meadow Creek near mouth (Figure 11):

The Meadow Creek watershed is sparsely populated. The towns of Meadow Bridge and Meadow Creek are the only population centers located therein. The STP at Meadow Bridge has some infiltration/ inflow (I/I) problems and operation deficiencies which sometimes contribute only partially treated wastewater to Meadow Creek. The WV DNR stocks trout once each month, February-May in the stream as a put-and-take fishery.

In 1987 only May exhibited a geometric mean greater than the standard of 200 counts/100 ml. At 219, the figure is relatively low. The pattern shown in Figure 11 is typical of streams which have non-point sources of FC. Note the higher levels April through June followed by lower levels July through September. Three violations of the second part of the FC criterion, i.e. not to exceed 400 counts/100 ml in more than 10% of the samples, contributed to the higher geometric means in April, May and June of 1987. They were 500 in April, 3,700 in May and 540 in June. Spring flows are usually higher than summer flows and so the flushing effect of runoff is seen in this pattern. If point sources are influenced by stormwater, as is the case with the Meadow Bridge STP collection system, they too can contribute to a pattern similar to the one demonstrated in 1987 on Meadow Creek. The effect of drought in 1988 is pronounced on the graph. Note that there is no clear

spring/fall-high/low pattern. One violation (800) of the second portion of the FC criterion alone was detected in May of 1988, while two (540 and 1,200) were observed in August that same year. July and September were the only months in 1988 to exhibit geometric means above the first part of the standard; 415 and 223 respectively. The second part of the criterion was exceeded also. These violations were likely due to the flushing effect of rainfall. Indeed, on the two days when the highest counts in September were obtained, 460 on September 6 and 440 on September 20, the sampler noted that the flow was high, i.e. higher than the unusually low drought-induced base flow. The same is true of July 19 when a count of 1,600 colonies was obtained. These runoff events were the result of local storms that helped ease the drought, but flushed FC into the streams. The highest concentration detected was >10,000 on July 12. The sampler that day was not the inspector who had been sampling all year. While he noted on the sample request form that the flow was low, when questioned further he indicated that it could have been higher than the drought-induced base flow, but he was not familiar enough with the area to make a clear judgement. This is the only likely explanation since rainfall had occurred the previous day in the vicinity of Meadow Creek. This instance points out the importance of stream flow data in performing more detailed and accurate interpretation of results.

T-2, Laurel Creek near mouth (Figure 12):

Laurel Creek has a few clusters of houses within its watershed, but it is relatively unpopulated. It was sampled only in 1987. FC values were low, all but one sample (1,120 counts/100 ml in May) had values below 200. Ten samples had <10. The highest monthly geometric mean occurred in May at 44. The low counts obtained in 1987 were responsible for the decision to refrain from sampling Laurel Creek in 1988. It did exhibit the pattern normally associated with runoff-induced FC contamination albeit at a very low level. Figure 12 displays the pattern of the geometric means clearly.

T-3, Piney Creek at mouth (Figure 13):

Piney Creek is the largest tributary to New River in NRGNR. Both the Beckley and North Beckley STPs have I/I problems causing overloading at the plants and overflows from the collection systems into the watershed. Compliance Sampling Inspections have turned up discharges from the facilities with FC concentrations in the tens of thousands and hundreds of thousands. Intensive surveys on Piney Creek have shown that despite the distance of nearly 10 miles from the STPs to the stream's mouth, enough FC survive to indicate an unusually high human health risk over the entire stretch. Kayakers occasionally run Piney Creek at high flows. NRGNR maintains a boaters' access site at the mouth of Piney Creek.

In 1987 every month sampled except August had geometric means greater than the standard of 200 counts/100 ml. In August, the 400 counts/100 ml part of the criterion was exceeded once (3,700). However, a clear pattern of high concentrations during spring flows vs. low levels during summer flows is exhibited in Figure 13. The

highest count obtained in 1987 was >30,000 on June 2. In 1988 Piney Creek violated both parts of the standard in every month except August when only the geometric mean portion of the criterion was exceeded. The highest count was 140,000 on July 19. Even though the drought was a strong influence on flows and FC concentrations that year, Piney Creek nonetheless exhibited an almost typical spring-summer pattern of FC contamination. The extremely high FC level of 140,000 obtained on July 19 during high flow from storm runoff skewed the data in July, otherwise the pattern is fairly clear.

T-4, Dunloup Creek near mouth (Figure 14):

The drainage area of Dunloup Creek includes the town of Mount Hope and several small communities. White Oak Public Service District (PSD) and the town of Mount Hope have STPs which discharge into Dunloup Creek. Both of these facilities have I/I problems which cause overflows on occasion. The Mt. Hope plant is overloaded and bypasses only partially treated sewage frequently. Overflows in the collection system during moderate precipitation intensities are common. Some pasturage along the upper portions of a few tributaries may contribute FC when intense runoff occurs, but the contributions would undoubtedly be masked by the high levels added by the two STPs and their collection systems.

During February-May the WV DNR maintains a put-and-take fishery in the lower part of Dunloup Creek by stocking trout once each month. One rafting company and many private boaters gain access to New River at Thurmond via a put-in point on Dunloup Creek near its mouth.

In 1987, the full FC stream criterion was exceeded in every month except September. April-July exhibited FC geometric means above the 200 counts/100 ml part of the standard. The lowest was 1,527 in April and the highest was 2,159 in May. In August and September the figures were much lower, 145 and 86 respectively, indicative of lower flows and thus of less contamination from overflows in the Mt. Hope and White Oak PSD STPs. The second portion of the standard was exceeded in August with one sample having a concentration (>6,000) greater than 400 counts/100 ml. The only month in 1988 which had a geometric average below the standard was September at 135 although August was barely above the criterion at 270. However, the 400 counts/100 ml portion of the criterion was exceeded in September with a concentration of 540. The geometric means from April through July were lower in 1988 than in 1987 demonstrating the effect of the drought on stormwater runoff during the traditional spring and early summer wet period.

T-5, Arbuckle Creek (Figure 15):

The STPs of Oak Hill and Arbuckle Public Service District at Minden discharge partially treated sewage into Arbuckle Creek during high precipitation runoff events. Both suffer from I/I problems. The Oak Hill plant is overloaded and some lift stations along the collection system overflow frequently even during relatively dry periods.

Arbuckle Creek was added to the FC sampling network in 1988 because previous data from the WV DNR ambient water quality monitoring program and the WV DNR/NPS sampling effort from 1980 through 1984 indicated that the stream was badly polluted by sewage.

In every month sampled, Arbuckle Creek experienced violations of the standard of 200 counts/100 ml as a geometric mean. The lowest was 797 in April and the highest was 1,458 in June. No clear pattern can be seen. The high FC concentrations found throughout the sampling period support the notion that the overloaded Oak Hill STP and collection system, and the sewer system of Arbuckle PSD are continual sources of sewage contaminants in Arbuckle Creek.

T-6, Wolf Creek at mouth (Figure 16):

Wolf Creek drains the area around Fayetteville which, despite recent growth in housing development, still has many acres in pasture. The pasture could conceivably contribute FC to the creek during heavy runoff periods, but this potential contribution would be masked by the raw sewage that pours from the overloaded lift station on House Branch of Wolf Creek during such events. During drier weather the lift station is able to pump sewage over to the overloaded STP in the Marr Branch watershed where it is only partially treated.

The lower portion of Wolf Creek is managed as a put-and-take trout fishery by the WV DNR through monthly stockings, during February-May. The beach on New River at the creek's mouth is a favorite recreation spot.

Predictably, during the sampling period in 1987 the only violations of the 200 counts/100 ml part of the criterion occurred April-June during the spring-early summer wet period. The pattern is a classical example of the effect which I/I overloading in a sewage collection system has on a stream. The lower concentrations during the same months in 1988 indicate that the drought had a beneficial effect on Wolf Creek as far as sewage contamination is concerned. There were no violations of the geometric mean portion of the criterion in 1988. However, concentrations of FC in excess of the 400 counts/100 ml portion of the standard were detected in April (410 twice), May (520) and September (490 and 1,350). The highest geometric mean obtained in 1988 was 110 in August. The highest in 1987 was 1,767 in April. The lowest for both years were 14 in August, 1987 and 14 in June, 1988.

T-7, Marr Branch (Figure 17):

Marr Branch is the stream most affected by sewage in NRGNR, although Arbuckle and Piney Creeks vie for second place, and Dunloup Creek is a not too distant fourth according to the FC data generated in this study. Fayetteville's STP, located on a tributary of Marr Branch is overloaded during some periods by an estimated three times as much flow as it is designed to handle. In 1982 a Division of Water Resources intensive survey of Marr Branch and the unnamed tributary which receives effluent from the facility showed the gross negative impact the discharge had upon those waters. Marr Branch

lies along part of the road which travels from U.S. Rt. 19 to Fayette Station (actually South Fayette), a popular recreation spot. Tour buses, rafting company buses, anglers, hikers of the Mary Draper Ingles Trail and car loads of sight-seers pass Marr Branch by the tens of thousands each summer. A private rafting company with a campground is located at the confluence of the unnamed tributary and Marr Branch. All of the company's staff and customers as well as the thousands of people travelling the road to and from South Fayette are exposed to the sickening smell and unsightly appearance of the streams. Some rafters, apparently unaware of the health risk, shower under a cascade of Marr Branch near its mouth at times when the odor is not unbearable. No sampling was conducted on Marr Branch under the WV DNR/NPS agreement in 1987 although one sample was collected on August 6, 1987 which resulted in a FC level of 27,000 counts/100 ml. However, an overview of past data collected from Marr Branch and the possibility of negative impacts on West Virginia citizens, visitors to NRGNR, and private enterprise contributed to the decision to further quantify the pollution problem by sampling in 1988. The sampling location is on Marr Branch about 1 mile upstream of its mouth and about 1000 yards downstream of its confluence with the sewage-laden unnamed tributary. During normal winter and spring flows, Marr Branch can be expected to significantly dilute the waste load carried by the tributary. Of course FC levels in the unnamed stream are higher than those detected at the sampling site and conversely FC concentrations at the mouth of Marr Branch are expected to be lower than those at T-7. Marr Branch cascades through a series of waterfalls from a point just below T-7 to the stream's mouth. Aeration over that section probably kills many of the FC bacteria, but violations of the stream criterion at the mouth of Marr Branch are still very likely.

The highest FC concentration obtained from any of the sample points over the two year study period was >940,000 on June 30, 1988 from Marr Branch. This figure of almost one million - indeed since they were too numerous to count the actual figure may be over one million - is comparable to some STP influents. The highest geometric mean for Marr Branch was 205,094 in July. Every one of the five samples collected that month were at or above 100,000 counts. For each of those five samples the sampler noted that the stream flow was low. The only relief to Marr Branch is during high flow when I/I dilutes the influent and thus the effluent is less concentrated. For most STPs high I/I causes overloading problems, but the Fayetteville STP is so overloaded even during drought periods that stormwater helps dilute the influent which normally passes through the plant nearly untreated. The lowest geometric mean obtained from Marr Branch was 608 in April when spring runoff, depressed though it was, helped dilute the polluted stream water. Because I/I helps to dilute the sewage passing through the facility, a pattern almost reversed from the usual pattern is noticeable. Lower FC concentrations are found during the spring and early summer while mid and late summer levels are much higher. The only other sample point with high concentrations comparable to Marr Branch is on New River just below the discharge from Hinton's overloaded and antiquated STP.

CONCLUSIONS

In 1987, violations of the first portion of the water quality standard for FC (200 counts/100 ml expressed as a monthly geometric mean based on no less than five samples) occurred in April at all nine sampling locations on New River. Violations occurred in May at six sites; N-2, N-5, N-6, N-7, N-8 and N-9. New River below the Hinton STP, N-2, experienced violations for the remainder of the sampling period in 1987 while all other mainstem sites had monthly geometric means below the standard. All New River sampling points except N-2 displayed seasonal patterns of FC contamination in 1987 typical of most West Virginia streams affected by non-point sources of animal wastes. Even streams with no human settlement and no livestock located in their watersheds will exhibit higher FC levels in spring than in summer since the greater spring runoff carries wild animal waste products into the streams. However, point sources such as STPs can also increase FC levels in receiving waters during precipitation events if they receive wastewater from combined stormwater/sewer systems in quantities which the facilities cannot adequately treat. N-5, New River at Meadow Creek, displayed higher FC geometric means in April and May of 1987 than all of the other mainstem stations except N-2. Those greater levels may have been due to poor quality effluent from the Meadow Creek STP during stormwater inflow overloading. While the facility is well run it may experience some inflow occasionally. This is uncertain. Streams which have fairly constant sources of human or animal wastes discharging into their waters often exhibit a secondary peak in FC concentrations during the low flow months of August, September and October. Wastewater treatment facilities are perhaps the most obvious contributors of such wastes, but local duck and beaver populations can regularly add FC in noticeable quantities. Livestock feed lots or barn yards may contribute high FC concentrations to nearby streams year round. Seasonal dwellings with direct discharges of domestic wastewater can cause summer FC peaks to be greater than under other conditions. Any or all of these types of sources may have contributed to the secondary peaks exhibited by the monthly geometric means of four sites on the New River mainstem in 1987; N-1, N-3, N-4 and N-5. Alternately, these peaks may simply be artifacts of the sampling times. For instance the apparent peak in September of 1987 for N-5 was due to one unusually high concentration obtained during the month. The figure of 3,300 from the sample collected September 8 skewed the geometric mean, albeit less so than it affected the arithmetic mean. To be sure that these peaks are not artifacts would require sampling over several years to demonstrate the repeatability of results.

On mainstem sites in every instance when geometric means exceeded the first part of the criterion, the second portion, i.e. no more than 10% of samples greater than 400 counts/100 ml, was also exceeded. There were a few violations of the second part of the FC stream criterion at most mainstem sampling sites during months when the geometric means did not exceed the first part of the standard. These scattered, high concentrations might have been due to any of the several factors discussed earlier, e.g. waterfowl defecation, intermittent discharges from seasonal dwellings, etc., but until more intensive research is conducted, cause and effect relationships cannot be firmly established.

The site located a few hundred yards downstream of the Hinton STP discharge, N-2, was grossly polluted by the effluent. Fortunately, New River dilutes the wastewater and begins the process of assimilation immediately upon receiving it. There is a distance of about 1 mile between the outfall and the nearest developed area downstream on the same side as the STP. The area contains a campground and a youth camp where anglers, swimmers and boaters enter New River. In 1988, N-2 again experienced violations of the stream standard every month it was sampled. No clear pattern was exhibited although in both years the highest monthly geometric means were in summer months; 47,652 in July, 1987 and 51,572 in August, 1988.

The other mainstem sampling stations did not exhibit the pattern in 1988 which was evident in 1987, i.e. higher FC geometric means in spring than in summer. However, five sites (N-1, N-3, N-4, N-6 and N-7) either displayed a summer peak or had a few geometric means in the summer months which were greater than those in April and May. Other than N-2, only N-3 and N-5 had violations of the water quality standard in 1988. High FC concentrations resulting from individual samples at N-5, New River at Meadow Creek, were probably due to the abundance of duck feces present at the site at the times of sampling. The puddle-like sampling site at N-5 was a favorite dabbling spot for local ducks. At N-3, New River at Brooks Falls, the summer peak in 1988 occurred in August just as it did in 1987. These peaks may indicate an annual pattern or they may be circumstantial. Further sampling would be necessary to establish the recurrence of a pattern.

It is obvious from the data generated in 1988 that the extensive drought experienced in West Virginia from the summer of 1987 through the summer of 1988 had a noticeable effect on New River water quality in NRGNR. The relatively low FC concentrations found in the spring of 1988 at all sampling points except N-2 are the most evident effects. The higher summer peaks in 1988 compared to 1987 are probably also effects of the drought. Within the three month period of July-September seven sites (N-1, N-3, N-4, N-5, N-6, N-7 and N-9), excluding N-2, had higher peaks in 1988 than in 1987; However, only two sets of seasonal data are not enough to ascertain whether or not the drought was the primary cause of the higher FC summer peaks at these stations.

Overall, the water quality of New River in NRGNR during the prime recreation season as indicatd by FC concentration appears relatively good. As noted previously, FC is not always an excellent indicator of the presence or absence of pathogens. High FC counts certainly indicate high concentrations of sewage and/or animal wastes and associated disease agents, but low FC counts may lead one into a false sense of security where conditions are favorable to certain pathogenic organisms but not to FC. Therefore, this report is limited in its ability to determine the health risk over the section of New River considered herein. Water-based activities are probably riskier to health during normal spring flows than during summer flow regimes since this study showed that FC concentrations at all sites except N-2 were higher during normal spring flows in 1987. The extremely high FC levels immediately

below the Hinton STP are indicative of a high human health risk which may extend downstream on the same side for over 1 mile. The Bass Lake recreation area and Brookside youth camp are probably at a greater health risk than most other places along the New River mainstem within NRGNR. The Meadow Creek access site may also have an elevated health risk associated with the duck feces and perhaps with the Meadow Creek STP. Other mainstem locations which may present health risks due to sewage pollution are in the vicinity of polluted tributaries. New River immediately below Marr Branch and Piney, Dunloup and Arbuckle Creeks may have health risks associated with the relatively high waste loads carried by those streams as indicated by frequent violations of the FC stream standard found in those tributaries during this study.

Marr Branch appeared to be more grossly polluted with sewage, as indicated by FC, than any other stream sampled in this study. Arbuckle, Piney and Dunloup Creeks had high FC concentrations similar to each other and indicative of heavy sewage loads. Violations of the standard occurred at the mouths of Meadow and Wolf Creeks usually only during periods when the stream levels were relatively high or recently increased by precipitation runoff. Levels of FC near the mouth of Laurel Creek were low during every month sampled in 1987, thus no sampling was performed in 1988. The portion of Laurel Creek which lies within the NRGNR boundary is swift, cold, relatively clean and secluded.

It is possible that I/I problems in the collection system of the Meadow Bridge STP were the sources of FC contamination noticeable in Meadow Creek during higher runoff events. Lower concentrations at low flows tend to substantiate this conclusion, but, even if the facility was a continuous source of high FC levels, slower stream velocities and higher water temperatures during low flow periods could decrease survival of FC and result in lower levels at the sampling site which is located several miles from the STP. However, the I/I problems and operation deficiencies were the more likely contributors to FC increases in Meadow Creek during the study period. By far the greatest contribution to elevated FC counts in Wolf Creek at higher flows came from I/I problems which overloaded the lift station on House Branch and caused it to bypass raw sewage. Drought conditions in 1988 prevented this from occurring during the sampling period. However, during the heaviest angling period, concurrent with trout stocking February-May, FC levels in the thousands can be expected to be common. The beach on New River at the mouth of the creek is a very popular recreation spot and recreationists themselves have been known to drink directly from Wolf Creek. Therefore, a human health threat exists in the stream which could be mitigated by upgrading the Fayetteville sewage collection system.

High FC counts in Arbuckle, Piney and Dunloup Creeks could be decreased dramatically by improvements in domestic wastewater collection systems and by upgrading STPs located in their watersheds. The Oak Hill STP is overloaded even during low flow periods. I/I is a major contributor to the facility's problems and overflows in the collection system are commonplace. Oak Hill is participating in the construction grants program administered by the WV DNR and funded by the United States Environmental Protection

Agency (EPA), but new construction will only address the plant, not the collection system. A new plant will be built to handle some of the sewage now flowing to the old plant. The Arbuckle PSD plant is fairly well maintained and operated, but I/I causes overflows occasionally and the collection system is not being upgraded. Thus it appears that high FC counts will continue to be found in Arbuckle Creek and it will be plagued with sewage related problems. Presently the human health risk is relatively low along lower Arbuckle Creek since few people are exposed to it. The mouth of Arbuckle Creek is frequented by local anglers and a few hikers and horseback riders cross it, but with the future extension of the Mary Draper Ingles Trail, public access to this sewage-laden stream will increase. The stretch of stream flowing through Minden poses a greater health risk since many people live along its banks.

Piney Creek has experienced serious degradation for many years due to discharges from the Beckley and North Beckley STPs and overflows from their collection systems. With funds from the construction grants program, Beckley recently upgraded its treatment facility, but the efficiency of the improvements remains to be seen especially since nothing substantial has been done to improve the combined stormwater/sewage collection system. The Beckley plant has been plagued by overloads from the sewer ever since the STP was constructed. The same is true of the North Beckley facility. I/I causes overloading of the STPs and collection systems frequently. Even during the drought in 1988 Piney Creek showed a geometric mean above the 200 counts/100 ml standard each month it was sampled. The highest concentration found, 140,000, was sampled during a stormwater runoff event, but many counts above 1,000 were obtained during very low flow conditions. There is a relatively high human health risk at the mouth of Piney Creek since the NPS maintains a boaters access site there and since there are several dwellings located there.

The White Oak PSD's STP on Dunloup Creek is in good shape and operates well under normal and low flow conditions, but it does suffer from stormwater inflow. However, the PSD is in the process of alleviating some of these problems now. By far the major contributors of high FC concentrations to the creek are the Mt. Hope STP and the community of Kilsyth. The Mt. Hope plant is antiquated and overloaded even during normal winter and spring flows, and the collection system overflows frequently due to I/I. The treatment plant is actively involved in the construction grants upgrading program, but the collection system is not being improved. Most of the households in Kilsyth discharge domestic waste directly into Dunloup Creek. Attempts to form a PSD to pursue the possibility of connection into the Mt. Hope collection system have failed. Since much of the sewage finding its way into the Dunloup Creek watershed is from collection system overflows and direct household discharges, it is unlikely that STP upgrading will improve the stream's water quality significantly during even moderately high runoff events. Dunloup Creek gets heavy fishing pressure during the stocking period. Several dwellings and businesses are located along the stream in the communities of Glen Jean, Red Star and Harvey. At the mouth one rafting company and many non-commercial boaters utilize an access point on the creek to "walk" their rafts down to New River. As a result of this human activity, Dunloup Creek poses one of the

highest health risks in the NRGNR area.

The town of Fayetteville has been able to put off compliance with water quality standards and permit limitations for years. The community has grown in recent decades with the expansion of tourism opportunities brought first by the rafting industry and then by NRGNR. However, wastewater treatment has been woefully neglected. The town's STP is a well-designed plant, but it sometimes is operating with three times as much flow as its design capacity allows. The problem is not just an I/I problem due to the old, combined stormwater/sewer collection system, it is also an overloading problem due to too many new hook ups allowed without proper upgrading of the facilities. The effluent is always of poor quality and it contributes more flow to the receiving stream than that tributary to Marr Branch already contains. The result is a grossly polluted, smelly creek full of red midge larvae, sewage fungus and foam, all of which are indicators of heavy organic pollution. During the summer months the odor is sickening. One rafting business, complete with campground and picnic area, is located along Marr Branch. It is unfortunate that the company's clientele and staff must bear the stench in summer. As mentioned earlier, the popular road to South Fayette brings tens of thousands of people within sight and smell of the stream. The extremely high FC counts obtained from Marr Branch during this study indicate that a high health risk exists for anyone coming into contact with the stream. Recently Fayetteville had a facility plan developed. Results of a sewer system evaluation survey will be used in decisions involving the collection system. There is a potential federal funding source for a design phase of upgrading the STP, but the construction phase will likely be several years away. Funds from the construction grants program will no longer be available at that time.

To summarize, this study indicates that except for a few local areas along New River's banks, most of the stretch of river that lies within NRGNR contains relatively low FC concentrations during most of the peak, water-based recreation season of April-September. The locales with higher FC concentrations are immeditely below the Hinton STP and at the Meadow Creek access site. Other sites of concern are immediately downstream of tributaries with high FC levels, i.e. Marr Branch, Piney Creek, Dunloup Creek, Arbuckle Creek and Wolf Creek in spring. Most violations of the stream standard of 200 FC colonies/100 ml of sample (expressed as a monthly geometric mean based on no less than five samples) at mainstem sampling sites occurred in the spring of 1987. While that spring was considered typical as regards stream flow, a drought gripped West Virginia the remainder of the year and through the summer of 1988. Low FC levels from the mainstem sites in the spring of 1988 are evidence of the drought. The higher concentrations of the summer of 1988 as compared to those of 1987's summer were probably also due to effects of the drought on flow regimes and runoff intensities.

The tributaries sampled in this study varied widely in their FC concentrations. The Laurel Creek site had the lowest levels. The Meadow Creek and Wolf Creek sites had relatively low levels with only occasional violations of the stream standard. Piney,

Dunloup and Arbuckle Creeks are sorely polluted by sewage as evidenced by the high FC counts detected during this study. The sampling site on Marr Branch had the highest monthly geometric mean and the highest individual sample FC concentration of any location sampled during the study period. New construction associated with the wastewater treatment system of Hinton will likely improve the quality of New River water immediately below the discharge. Other improvements funded under the construction grants program of the EPA will be made at Oak Hill and Mount Hope. The improvements at Mount Hope's STP may decrease the sewage load in Dunloup Creek, but continued problems in the collection system and direct sewage discharges from Kilsyth may mask the beneficial effects. Until improvements are made in the collection systems of Oak Hill, Arbuckle PSD and the two Beckley STP's, high FC levels can be expected in Arbuckle and Piney Creeks. The future of Marr Branch is bleak. Since Fayetteville will not be involved in the construction grants process after 1989, improvements will likely have to be funded entirely by those who are serviced. While the EPA's revolving loan fund will be available to grant low-interest loans to communities which want improvements in sewage treatment, historically high costs have prevented communities from being involved in the construction grants program which funded portions of the costs of improvement outright. Therefore, the less attractive low interest loans may not be effective in the near future in improving STPs and collection systems which degrade the waters of NRGNR.

RECOMMENDATIONS

In conjunction with the state health department, the NPS may consider placing warning signs at sites which give public access to the more heavily polluted tributaries. Signs which warn that the water is not potable could be placed at public access points along Piney, Dunloup, Arbuckle and Wolf Creeks, and Marr Branch. In addition, rafting companies should be advised to warn their customers and staff not to drink from these streams.

The sewage problems associated with the tributaries sampled during this study are likely to continue at least until the STPs within their watersheds are upgraded as proposed. At that time a sampling scheme similar to that utilized for this study could be used to determine the level of improvement in the affected streams. Funding for improvements in the sewage collection systems and the treatment plants discussed in this report should be pursued by the communities served with assistance from the WV DNR and the EPA. Special appropriations from the United States Congress should be considered if the poor tax base of some communities will impede progress toward improvements. The potential impact of water-borne pathogens on large numbers of visitors to NRGNR and to West Virginia residents in the NRGNR area necessitates the speedy mitigation of sewage related problems on tributaries within the park boundary.

Several tributaries to New River within the NRGNR boundary have not been sampled by the WV DNR in previous studies. Some of those are in remote locations and may be utilized by hikers, horseback riders and boaters while they are travelling through or camping in the gorge area. It would probably be beneficial to know the water

quality of those streams. A program of sampling for conventional pollutants on a quarterly basis for one year would probably be sufficient for assessing the status of those tributaries.

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APPENDIX

LIST OF ABBREVIATIONS

EPA = United States Environmental Protection Agency

FC = Fecal coliform bacteria

I/I = Infiltration/Inflow

NPS = National Park Service

NRGNR = New River Gorge National River

PSD = Public Service District

STP = Sewage treatment plant

WV DNR = West Virginia Department of Natural Resources

Table 3 New River Gorge National River Fecal Coliform Study
Tables of Fecal Coliforms Values
During Recreational Periods, April to September, 1987

Date	N-1, New R. at Hinton Visitors Center	N-2, New R. at Hinton Sewage Treat. Plt	N-3, New R. at Brooks Falls	N-4, New R. at Sandstone Falls
08APR87	280	410 *	170	190
14APR87	70	20	80	60
16APR87	360	780 *	340	260
20APR87	360	2,150 *	610 *	500 *
30APR87	900 * +	> 5,500 * +	1,380 * +	1,060 * +
07MAY87	700 *	> 17,100 *	340	440 *
13MAY87	40	> 14,200 *	20	20
21MAY87	20	20,000 *	120	480 *
26MAY87	50	5,400 *	120	160
28MAY87	120	900 * +	20	260
02JUN87	< 10	400 *	20	40
04JUN87	40	> 30,000 *	20	90
11JUN87	10	200	10	30
24JUN87	30	250	30	30
30JUN87	100	80 +	< 10	< 10
09JUL87	30	> 20,000 *	50	10
14JUL87	30	> 300,000 *	20	60
16JUL87	30	140,000 *	20	40
21JUL87	10	7,500 *	180	40
28JUL87	20	39,000 * +	710 *	100
04AUG87	100	3,600 *	630 *	120
06AUG87	60	> 125,000 *	40	150
11AUG87	60	1,850 *	850 *	60
18AUG87	10	> 300,000 *	560 *	20
26AUG87	90	150 +	20	< 10
02SEP87	40	700 *	40	40
08SEP87	50	420 *	20	280
16SEP87	10	250	20	40
22SEP87	< 10	> 120,000 *	370	120
24SEP87	< 10	400 +	< 10	10

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+ Indicates monthly sample sets in which the geometric mean was greater than 200 counts per 100 ml

Table 3 (cont.) New River Gorge National River Fecal Coliform Study
Tables of Fecal Coliforms Values
During Recreational Periods, April to September, 1987

Date	N-5, New R. at Meadow Creek	N-6, New R. at Mc Creery Access	N-7, New R. at Stonecliff Beach	N-8, New R. at Thurmond Access
08APR87	200	240	320	260
14APR87	80	10	50	20
16APR87	5,400 *	310	490 *	320
20APR87	1,080 *	470 *	800 *	1,080 *
30APR87	1,000 * +	1,450 * +	480 * +	450 * +
07MAY87	500 *	320	120	100
13MAY87	140	230	130	200
21MAY87	620 *	120	1,350 *	1,350 *
26MAY87	> 19,300 *	560 *	200	200
28MAY87	8,400 * +	200 +	260 +	100 +
02JUN87	450 *	100	2,400 *	1,900 *
04JUN87	240	40	60	20
11JUN87	80	20	100	60
24JUN87	620 *	40	40	20
30JUN87	40	< 10	< 10	< 10
09JUL87	240	450 *	90	< 10
14JUL87	320	170	70	240
16JUL87	470 *	40	< 10	110
21JUL87	30	< 10	< 10	< 10
28JUL87	20	< 10	10	20
04AUG87	< 10	10	10	< 10
06AUG87	310	60	460 *	290
11AUG87	50	10	20	< 10
18AUG87	60	< 10	< 10	< 10
26AUG87	10	< 10	< 10	< 10
02SEP87	20	< 10	< 10	< 10
08SEP87	3,300 *	170	280	1,040 *
16SEP87	110	20	10	20
22SEP87	10	30	< 10	30
24SEP87	50	30	< 10	10

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Table 3 (cont.) New River Gorge National River Fecal Coliform Study
Tables of Fecal Coliforms Values
During Recreational Periods, April to September, 1987

Date	N-9, New R. at Fayette Station	T-1, Meadow Creek near mouth	T-2, Laurel Creek near mouth	T-3, Piney Creek at mouth
08APR87	580 *	340	60	4,400 *
14APR87	80	20	< 10	550 *
16APR87	250	280	30	1,500 *
20APR87	660 *	120	10	2,350 *
30APR87	580 * +	500 *	20	3,950 * +
07MAY87	190	20	< 10	1,340 *
13MAY87	70	120	10	2,700 *
21MAY87	210	380	1,120 *	> 9,900 *
26MAY87	580 *	3,700 *	140	650 *
28MAY87	260 +	150 +	10	1,140 * +
02JUN87	2,000 *	240	60	> 30,000 *
04JUN87	300	70	70	700 *
11JUN87	200	540 *	10	600 *
24JUN87	< 20	90	30	3,600 *
30JUN87	30	40	10	500 * +
09JUL87	300	120	30	840 *
14JUL87	20	110	100	300
16JUL87	100	30	10	120
21JUL87	10	10	10	160
28JUL87	< 10	20	< 10	110 +
04AUG87	< 10	70	< 10	40
06AUG87	740 *	40	< 10	3,700 *
11AUG87	20	< 10	10	60
18AUG87	10	< 10	< 10	10
26AUG87	10	10	< 10	120
02SEP87	< 10	< 10	< 10	230
08SEP87	110	110	10	1,000 *
16SEP87	40	30	20	140
22SEP87	40	10	< 10	200
24SEP87	10	< 10	< 10	150 +

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Table 3 New River Gorge National River Fecal Coliform Study
(cont.) Tables of Fecal Coliforms Values
During Recreational Periods, April to September, 1987

Date	T-4, Dunloup Creek near mouth			T-5, Arbuckle Creek at mouth			T-6, Wolf Creek at mouth			T-7, Marr Br. Rivers Campground		
08APR87	2,800	*					2,700	*				
14APR87	250						1,900	*				
16APR87	2,550	*					> 6,900	*				
20APR87	2,450	*					2,700	*				
30APR87	1,900	*	+				180		+			
07MAY87	5,300	*					40					
13MAY87	3,400	*					20					
21MAY87	2,000	*					560	*				
26MAY87	1,550	*					> 6,600	*				
28MAY87	840	*	+				440	*	+			
02JUN87	8,500	*					> 10,000	*				
04JUN87	3,100	*					500	*				
11JUN87	1,300	*					2,150	*				
24JUN87	800	*					60					
30JUN87	500	*	+				10		+			
09JUL87	> 22,000	*					40					
14JUL87	650	*					260					
16JUL87	650	*					20					
21JUL87	2,500	*					< 10					
28JUL87	800	*	+				10					
04AUG87	40						60					
06AUG87	110						10					
11AUG87	> 6,000	*					10					
18AUG87	20						< 10					
26AUG87	120						10					
02SEP87	100						20					
08SEP87	210						40					
16SEP87	40						60					
22SEP87	50						20					
24SEP87	110						10					

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Table 4 New River Gorge National River Fecal Coliform Study
Tables of Fecal Coliforms Values
During Recreational Periods, April to September, 1988

Date	N-1, New R. at Hinton Visitors Center	N-2, New R. at Hinton Sewage Treat. Plt	N-3, New R. at Brooks Falls	N-4, New R. at Sandstone Falls
07APR88	20	130	10	< 10
11APR88	10	> 30,000 *	10	20
18APR88	20	64,000 *	< 10	20
26APR88	150	8,000 *	30	20
28APR88	20	23,000 * +	< 10	20
03MAY88	< 10	< 100	< 10	< 10
05MAY88	10	39,000 *	< 10	< 10
12MAY88	20	250	20	30
18MAY88	20	500 *	20	10
23MAY88	40	1,000 * +	20	< 10
02JUN88	40	700 *	10	50
08JUN88	10	1,700 *	140	40
14JUN88	40	420 *	< 10	10
21JUN88	60	2,200 *	130	40
30JUN88	40	> 314,000 * +	200	20
05JUL88	60	34,000 *	150	10
12JUL88	130	1,180 *	650 *	1,650 *
14JUL88	90	360	20	30
19JUL88	180	2,900 *	390	370
28JUL88	10	700 * +	150	110
01AUG88	20	> 200,000 *	390	60
08AUG88	100	400,000 *	470 *	20
17AUG88	40	3,800 *	300	20
24AUG88	100	4,000 *	280	< 10
30AUG88	60	> 300,000 * +	310 +	190
06SEP88	70	650 *	70	20
08SEP88	40	500 *	30	90
13SEP88	110	2,200 *	380	210
15SEP88	20	1,400 *	140	< 10
20SEP88	70	750 * +	20	160

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+ Indicates monthly sample sets in which the geometric mean was greater than 200 counts per 100 ml

Table 4 (cont.) New River Gorge National River Fecal Coliform Study
Tables of Fecal Coliforms Values
During Recreational Periods, April to September, 1988

Date	N-5, New R. at Meadow Creek	N-6, New R. at Mc Creery Access	N-7, New R. at Stonecliff Beach	N-8, New R. at Thurmond Access
07APR88	150	90	390	100
11APR88	120	< 10	20	60
18APR88	< 10	< 10	< 10	< 10
26APR88	50	50	40	60
28APR88	380	160	10	30
03MAY88	70	< 10	< 10	10
05MAY88	620 *	20	620 *	310
12MAY88	470 *	50	10	30
18MAY88	1,900 *	20	< 10	20
23MAY88	660 * +	10	< 10	20
02JUN88	900 *	10	30	50
08JUN88	80	10	< 10	< 10
14JUN88	340	20	< 10	10
21JUN88	1,100 *	50	160	80
30JUN88	200 +	10	< 10	< 10
05JUL88	40	10	< 10	< 10
12JUL88	> 30,000 *	50	90	< 10
14JUL88	20	80	60	40
19JUL88	1,000 *	1,100 *	> 1,430 *	180
28JUL88	580 * +	120	70	50
01AUG88	540 *	30	< 10	10
08AUG88	40	20	10	< 10
17AUG88	90	30	10	< 10
24AUG88	90	40	120	< 10
30AUG88	70	< 10	20	10
06SEP88	110	70	190	210
08SEP88	190	270	100	10
13SEP88	140	20	10	< 10
15SEP88	230	20	< 10	< 10
20SEP88	440 *	130	20	430 *

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Table 4 New River Gorge National River Fecal Coliform Study
(cont.) Tables of Fecal Coliforms Values
During Recreational Periods, April to September, 1988

Date	N-9, New R. at Fayette Station	T-1, Meadow Creek near mouth	T-2, Laurel Creek near mouth	T-3, Piney Creek at mouth
07APR88	340	220		> 4,350 *
11APR88	90	80		1,900 *
18APR88	10	< 10		6,700 *
26APR88	40	150		900 *
28APR88	40	100		620 * +
03MAY88	10	260		360
05MAY88	220	800 *		> 12,300 *
12MAY88	20	170		300
18MAY88	50	120		600 *
23MAY88	10	20		440 * +
02JUN88	90	< 10		160
08JUN88	< 10	20		260
14JUN88	60	20		200
21JUN88	< 10	400		5,300 *
30JUN88	< 10	20		150 +
05JUL88	< 10	40		80
12JUL88	70	> 10,000 *		1,600 *
14JUL88	760 *	240		1,700 *
19JUL88	40	1,600 *		140,000 *
28JUL88	80	80 +		240 +
01AUG88	70	70		400
08AUG88	10	540 *		120
17AUG88	20	20		260
24AUG88	30	1,200 *		380
30AUG88	30	< 20		110 +
06SEP88	80	460 *		3,000 *
08SEP88	< 10	70		300
13SEP88	10	140		600 *
15SEP88	150	280		570 *
20SEP88	40	440 * +		400 +

Values are in MF/100ML which means Counts of Colonies in Membrane Filter per 100 Milli Liters of Water

< means that the Value is less than one displayed
> means that the Value is greater than one displayed

* Indicates values greater than 400 counts per 100 ml
+ Indicates monthly sample sets in which the geometric mean was greater than 200 counts per 100 ml

Table 4 (cont.) New River Gorge National River Fecal Coliform Study
Tables of Fecal Coliforms Values
During Recreational Periods, April to September, 1988

Date	T-4, Dunloup Creek near mouth	T-5, Arbuckle Creek at mouth	T-6, Wolf Creek at mouth	T-7, Marr Br. Rivers Campground
07APR88	1,100 *	< 20,000 *	410 *	> 17,500 *
11APR88	200	400	410 *	750 *
18APR88	1,050 *	720 *	100	620 *
26APR88	160	200	30	20
28APR88	540 * +	280 +	10	510 * +
03MAY88	240	160	150	50
05MAY88	820 *	5,800 *	520 *	> 10,000 *
12MAY88	660 *	720 *	140	40
18MAY88	800 *	2,700 *	20	680 *
23MAY88	440 * +	400 +	< 10	> 12,300 * +
02JUN88	1,060 *	3,700 *	10	20
08JUN88	2,000 *	> 12,700 *	20	1,300 *
14JUN88	2,000 *	280	10	700 *
21JUN88	340	100	30	8,400 *
30JUN88	300 +	5,000 * +	10	> 940,000 * +
05JUL88	180	160	< 10	200,000 *
12JUL88	800 *	1,000 *	260	360,000 *
14JUL88	320	980 *	70	420,000 *
19JUL88	2,800 *	> 95,000 *	240	120,000 *
28JUL88	3,700 * +	60 +	20	100,000 * +
01AUG88	1,520 *	3,200 *	50	5,200 *
08AUG88	340	1,140 *	40	10,000 *
17AUG88	220	3,700 *	50	600,000 *
24AUG88	630 *	640 *	70	4,000 *
30AUG88	20 +	360 +	20	42,000 * +
06SEP88	540 *	4,100 *	490 *	1,950 *
08SEP88	120	320	60	1,200 *
13SEP88	230	840 *	40	58,000 *
15SEP88	60	4,100 *	1,350 *	5,100 *
20SEP88	50	160 +	10	21,000 * +

Values are in MF/100ML which means Counts of Colonies in Membrane Filter per 100 Milli Liters of Water

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> means that the Value is greater than one displayed

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+ Indicates monthly sample sets in which the geometric mean was greater than 200 counts per 100 ml